Edited by
Milena Valenčič Zuljan and Janez Vogrinc

Facilitating Effective Student Learning through Teacher Research and Innovation

Univerza *v Ljubljani*
Pedagoška fakulteta



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FOREWORD

Innovation of didactic and learning strategies is one of the basic demands in teacher training at all levels of education, as has been clearly recognized by the European Union. In its communication of 13th September 2007 entitled *Putting knowledge into practice: A broad-based innovation strategy for the EU*, the European Commission stressed the need for 'collective action to safeguard the European way of life that combines economic prosperity with solidarity' and said it was 'convinced that innovation in a broad sense is one of the main answers to citizens' material concerns about their future'. The Commission defines education as a precondition for creating a true European innovation space. As a core policy it must promote talent and creativity from an early stage.

The European Union Council of Education, Youth and Culture has stressed in its 2008 *Conclusions on promoting creativity and innovation through education and training* that creativity and the capacity to innovate are crucial to a sustainable economic and social development of Europe, and acknowledged that all levels of education and training can contribute to creativity and innovation in a lifelong learning perspective. The Council held that, starting at the level of individual schools, education systems need to combine the development of specific knowledge and skills with generic capacities linked to creativity, such as curiosity, intuition, critical and lateral thinking, problem solving, experimentation, risk taking and the ability to learn from failure, use of the imagination and hypothetical reasoning, and a sense of entrepreneurship. It stressed that teachers have a crucial role to play in nurturing and supporting each child's creative potential, and can contribute to this by exemplifying creativity in their own teaching; and that teacher education institutions also have a key contribution to make in providing teaching staff with the knowledge and competences required for change, such as the skills needed to promote learner-centred approaches, collaborative work methods and the use of modern learning tools, particularly those based on ICT. Fostering creative abilities and attitudes within schools also requires the support of an organisational culture open to creativity and the creation of an

innovation-friendly environment in general, as well as committed and forward-looking leadership at all levels.

I'm certain that the monograph *Facilitating Effective Student Learning through Teacher Research and Innovation* is a timely, necessary and important step in this direction. This has been recognized by the reviewers as well. I would like to recommend this book to readers with the words of one of the reviewers, Prof. Grozdanka Gojkov, who writes that the teacher's role "implies constant innovations of procedures in the pedagogic-didactic competences of a teacher, which is a guiding principle of all the researches in the present monographic study and its great value, having in mind that it is one in a small number of similar publications in Europe, dealing with innovation of didactic procedures of teachers from the angle of their new role, based on participatory epistemology. Numerous outcomes of empirical researches on the application of new procedures heading in this direction are precious, not only as facts on effects and possibilities of application, but as ideas for designing new relevant research frameworks and ideas for new actions. Truly convinced of the value of the present study, I express my admiration to the authors and congratulations to the publisher."

Janez Krek
Dean

INTRODUCTION

The UNESCO report of The International Commission on Education for the Twenty-first Century (1996) states that »none of the talents which are hidden like buried treasure in every person must be left untapped«. This triggers the question of what education can do towards this aim and how school can provide instruction that will best develop the potential of each individual. This is a key challenge for teachers, school managers, teacher trainers and policy makers at all levels alike. Finding a way to develop the learners' potentials and prepare them for lifelong learning in a constantly changing world hinges on the teachers' ability to be innovative. Only a professionally competent and innovative teacher can namely encourage learners to look for new ways and new knowledge themselves. Innovative problem-solving is a key competence in today's world, as is stressed also by the European Commission in A Memorandum on Lifelong Learning (2000).

The aim of this collection of papers is to introduce different aspects of innovation in the teaching/learning process and teachers' research work in different countries. In particular we wanted to shed light on:

- Ways of encouraging teacher and student innovation in different educational systems.
- Pedagogical innovations in different subject fields: descriptions of pedagogical innovations, their theoretical background and evaluation.
- Research into teacher-innovation factors (teachers' views on innovation, the role of the principal and the school climate etc).
- Teachers' competences and qualifications for innovation and research of their practice (training teachers in these areas in pre- and in-service programs etc.) and the scope of teacher engagement in research and innovation.
- The propositions of systematic and organizational changes required for quality implementation of innovation in the teaching process and teacher research.

The book is intended for teachers, teacher trainees, school managers, teacher trainers and policy makers in education – all those who shape the educational experience. It contains 20 papers contributed by researchers from 14 countries. Our heartfelt thanks go to all of the contributors for participating in the project.

Keith S. Taber from the University of Cambridge, UK, in his paper *Preparing teachers for a research-based profession,* takes a constructivist perspective on both teacher learning and student learning. He presents a case study from UK experience as an example of how effective research training can be included in teacher education courses, in ways that are integrated with the development of other professional skills. The starting point is the assumption that teaching *should be* an evidence-led and research-based profession: that is that teachers should be expected to both be aware of relevant research about teaching and learning, *and* to also be capable of undertaking small-scale classroom research to address professional issues and problems that arise in their work.

A group of researchers from Belgium, **Van Waes, S., Vanthournout, G., Gijbels, D., Donche, V., and Van Petegem, P**., looked into the question of learner training in higher education. Their paper *Fostering students' learning with study guides: The relationship with perception and learning patterns* presents research on students' use and perception of study guides in higher education. In a quantitative exploratory study, students' perceptions of study guides and the relation between their perceptions and learning patterns were analysed.

German researchers **Ingo Eilks, Silvija Markic and Torsten Witteck** authored the paper *Collaborative Innovation of the Science Classroom by Participatory Action Research – Theory and Practice in a Project of Implementing Cooperative Learning Methods in Chemistry Education,* in which they discuss how teachers' attitudes towards innovation can change drastically when a participatory approach is used.

In their paper *Academic teacher at the crossroads of innovation highways*, **Iwona Maciejowska and Marek Frankowicz** from Poland stress that every academic teacher is influenced by two streams of innovations: one related to general processes occurring in the art of pedagogy and organizational changes in higher education (such as the Bologna Process

in Europe), and the other connected with changes in his/her subject area. The Bologna "wind of change" favors national and institutional reforms, promotes quality culture, and accelerates a transition from teacher-centered to learner-centered education. The authors present a model of networking as a powerful tool to generate new quality in academic practice.

Syh-Jong Jang from Taiwan examined the impact of a transformative model of integrating technology and peer coaching for developing pedagogical content knowledge of pre-service science teachers in his paper *Using a transformative model of integrating technology and peer coaching to develop TPCK of pre-service science teachers.* A TPCK-COPR model and an online system were designed to restructure science teacher education courses. The study draws on four views (comprehensive, imitative, transformative and integrative) to explore the impact of TPCK. The model could help pre-service teachers develop technological pedagogical methods and strategies of integrating subject-matter knowledge into science lessons, and further enhance their TPCK.

The paper *Innovative instructional intervention and the need for a better insight into instructional conceptions* by a group of African and Belgian researchers, **Frederick Kwaku Sarfo, Jan Elen, Flip Louw and Geraldine Clarebout,** discusses the development of a survey for assessing students' general conceptions as well as measuring students' specific instructional conceptions about particular innovative instructional interventions.

The Polish researchers **Hanna Gulińska and Małgorzata Bartoszewicz** deal with distance learning as an innovative approach to training primary school teachers and chemistry teachers. Their paper *The effects of using the Share Point platform in teaching science students and teachers* is a detailed presentation of an innovative experiment without a broader theoretical background and an evaluation of the impact of the innovation.

A group of Thai and New Zealand researchers, **Richard K. Coll, Ninna Jansoon, Chanyah Dahsah, Sanoe Chairam,** contributed the paper *Fostering Teacher innovation in Chemistry teaching in Thailand: helping Thai Science Teachers Move Towards a Learner-Centred Student Classroom*. The

authors stress the importance of training teachers for active, innovative, learner-centered teaching, which is a novelty for teachers in Thailand.

Liberato Cardellini from Italy, in his paper *Acquiring and assessing structural representations of students' knowledge*, presents two useful tools for improving the quality of teaching. One tool is the concept map, an increasingly popular tool for helping students represent their knowledge by making explicit how they relate key concepts in a knowledge domain. Another is the word association test, a useful and quick tool for assessing the relationships, in the minds of our students, between the concepts taught. The use and the problems connected with these tools are presented and evaluated.

The emotional component of the process of innovation is discussed by Spanish researchers **Juan-Luis Castejón, Raquel Gilar and María-Luisa Pertegal**. The paper *Competence profile differences among graduates from different academic subject fields* presents the characteristic profile of competences of a sample of teachers in training, and compares it with the competence profile of graduate students from the fields of law, social sciences, humanities, science and technology, and health.

Héctor García Rodicio and **Emilio Sánchez** from Spain, authors of *Making instructional explanations effective. The role of learners' awareness of their misunderstandings*, present an experiment in which undergraduate students learned geology from a multimedia presentation. The presentation also included instructional explanations aimed at revising learners' misunderstandings, which were presented in combination with prompts (prompted explanation) or in isolation (rough explanation).

The Slovenian researcher **Urška Sešek** looks at the introduction of a web-based learning environment into a large higher education institution. Her paper *Are web-based learning environments transforming tertiary education? The case of a large humanities institution,* presents a survey carried out at the Faculty of Arts in Ljubljana two years after the introduction of a WBLE. As the approach taken was based on optional-innovation decision, the aim of the research was to profile the use of the WBLE as well as to assess its impacts.

Slovenian researcher **Maja Umek** presents her research in *Learning through photography in social science from the third to the fifth grade*. In the research she concentrated on the use of a digital camera and working with photographs in social science classes in elementary school. She emphasises that learning with images and demonstration as a teaching method are of great importance for the development of concepts and understanding of geographical and historical processes, especially with topics that are distant in time and space.

Czech researchers **Hana Svatoňová and Kateřina Mrázková,** in their paper *Geoinformation technologies: New Opportunities in Geography Education?,* present some possibilities of using geoinformation technologies, especially geographic information systems (GIS) and remote sensing in geography education. The study discusses the advantages and limitations of their usage. It also introduces some resources for teachers and students that can help them to become familiar with these technologies.

Slovenian researcher **Bogdana Borota** deals with music education in her paper *The impact of learning in the innovative computer environment Musical Image Format, Rhythm on musical achievements*. The paper presents a tool called *Musical Image Format, Rhythm*, an ICT learning environment based on the paradigm of constructivist learning and teaching. In Slovenia this is the first attempt of a transfer of the music image format into a digital environment. The results of the experiment suggest positive implications for the development of rhythmic abilities and skills as well as for the use of the musical rhythm image format.

Slovenian researchers **Mara Cotič, Milena Valenčič Zuljan, Blaž Simčič and Sanela Mešinović** are authors of the paper *Geometrical problems and the use of geoboard presents problem-oriented instruction of geometry with the use of the geoboard*. Geometry is considered to be very abstract, and is therefore difficult to be taught. Teachers usually deliver their instruction in a very formal way and a number of pupils have difficulties in geometry. For this reasons the researchers conducted an experiment in which they trialled a model of geometry instruction with the use of geoboard, a tool for setting and solving geometry problems.

Slovenian researchers **Iztok Devetak** and **Saša Glažar** authored the paper *Guided Active Learning in Chemistry*. When students use *GALC* approach they learn new concepts and connections between them in groups where the social context of learning takes place. *GALC* approach can be used by the students in school environment, but not so easy at home, because the method should be used in group learning.

Slovenian researcher **Mojca Juriševič**, in her paper *Creativity in the zone of proximal motivational development,* discusses the stimulation of creative thinking at school, which hinges on understanding the dynamics of motivation regulating pupils' learning behaviours. She discusses two levels of teaching, the cognitive and the motivational, which in the optimal proportions ensure the conditions for activating learners' higher-level thinking processes, which are a basis for creative thinking that leads to innovative achievements.

Ruth Zuzovsky and Esther Yogev from Israel authored the paper *Going public: pedagogical supervisors conceptualizing their pedagogical practices*, in which they summarize a two-year process through which a group of teacher educators, serving as pedagogical supervisors in a leading teacher training college in Israel – The Kibbutzim College of Education Technology and Art – went as they worked at conceptualizing, formulating and publishing their professional knowledge.

In the paper *The factors of encouraging teacher innovation from the perspective of teachers and headmasters* Slovenian researchers **Milena Valenčič Zuljan** and **Janez Vogrinc** present the results of a research into the question of which factors, from the perspective of Slovenian teachers and headmasters, could contribute to an increase in innovative teaching. The study revealed the teachers' and headmasters' self-assessments of their competence in planning, implementing and evaluating pedagogical innovations, the teachers' and headmasters' attitudes towards innovation and changing their teaching practice, and how this is related to their job satisfaction.

The papers in this collection are richly diverse both in terms of content and research and methodology. They deal with content fields ranging from art to science and humanities, and with different levels of education from elementary school to university. They differ in terms of

theoretical depth and approaches to research methodology; researchers illustrate the use of top-down and bottom-up approaches as well as a variety of research methods. Some papers present a specific innovation, focusing either on a detailed presentation of an experiment or on evaluating the impact of the innovation, while others discuss conditions which call for innovation or the question of what kind of context is most conducive to innovative teaching and learning. From a didactic point of view as well the papers are very diverse: some innovations presented refer ICT and other teaching aids, and some focus on teaching methods and approaches. A thread that runs through all the papers, however, is that, explicitly or implicitly, they testify to the importance of the teachers' didactic and subject-specific competences in the innovation process. Some papers clearly define the cognitive-constructivist approach as an appropriate basis for teacher action both in classroom teaching and in teacher training. Some papers pay special attention to teacher education and the key factors of teachers' professional activity and development.

We hope that readers will find in this collection of papers incentives and springboards for professional reflection as well as encouragement for research and innovation of teaching.

We are grateful to the Ministry of Education and Sports of Slovenia for the financing of the project ˝Encouraging a culture of research and innovation in schools through a process of lifelong teacher learning˝, which took place at the Faculty of Education in Ljubljana, and has enabled the publishing of this book.

Milena Valenčič Zuljan
and Janez Vogrinc

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EXTRACTS FROM REVIEWS

The papers included in this volume, both domestic and international, depart from a very topical and important question: **how to reshape our teaching so as to effect a deeper and more effective learning process,** not only through implementing innovation top down and attempts to transfer political decisions and theoretical findings into the schools (both of these have repeatedly proven unsuccessful in the past) – but by **strengthening the active role of the teacher as a researcher and developer of his/her own practice**. Of course these processes cannot take place on their own, without a strong cooperative role of university researchers and the support of the institutions of the educational system. Only a consistent and genuine synergy of all the stakeholders can lead to profound positive change in the perceptions and actions of teachers, and thus in the learners' learning processes and outcomes.

The main conclusion of all the contributors is that thorough change of educational practices requires **committed, long-term cooperation** between researchers and teachers in implementing theoretically supported change. Real change is not possible through short-lived, even though perhaps seemingly spectacular projects or 'high' computer technology. It is not so important whether teachers themselves initiate the innovation (in most cases they do not), but whether they were presented the innovation thoroughly and clearly enough, with enough theoretical justification, and whether the necessary conditions have been provided (sufficient training and broader environmental support).

Barica Marentič Požarnik
University of Ljubljana, Slovenia

Innovation of instructional and learning strategies is one of the basic issues of learning in teaching at all levels and systems of education; therefore it is no coincidence that in Slovenia the need has been recognized to undertake researches dealing with support to more efficient learning of students through research and innovative work of teachers.

The contributions reflect theoretical pluralism and anarchistic epistemology, carry a personal tone, stem from open, emancipatory, learner-centered pedagogy and are practically innovative. In the studies, the essence of contemporary, postmodern pedagogy and didactics is directed into "co-determined" learning, self-responsible and co-responsible action. At the same time, emancipatory pedagogy has omens for the tendency to relativise contents, it is inclined to open curriculum permeated by clear tones of anarchistic epistemology and avoidance of dogmatism of a method and theory, dogmatism of education of rational term, as well as unchangeable thinking principles.

Having in mind that the theoretical ground of the researches is a constructivist perspective, a teacher has been viewed from the angle of new roles. The main aspect of the teacher's role refers to the preparation of a context, i.e. creation of an encouraging environment including preparation of learning materials through various paths and canals and creation of social situations for learning and ways for an individual to attain insights and understanding of problems occurring during learning. The main features of a teacher have been pointed out: self-reflexivity, being able to encourage and care for the student and not to be too authoritative. All this implies constant innovations of procedures in pedagogic-didactic competence of a teacher, which is a guiding principle of all the researches in the present monographic study and its great value, having in mind that it is one of the few similar surveys in broader European space, dealing with innovation of didactic procedures of teachers from the angle of their new role, based on participatory epistemology. Numerous outcomes of empirical researches on the application of new procedures heading in this direction are precious, not only as facts on effects and possibilities of application, but as new ideas for designing new relevant research frameworks and ideas for new actions. Truly convinced of the value of the present study, we admire the authors and congratulate the publisher.

Grozdanka Gojkov
University of Novi Sad, Serbia

PREPARING TEACHERS FOR A RESEARCH-BASED PROFESSION

Keith S Taber
Faculty of Education, University of Cambridge, UK

ABSTRACT

The UK government has an aspiration to make teaching a 'master's level profession'. That is, in the future it will be expected that teachers should be qualified to at least Master's degree level. Initial teacher education courses in major UK universities now tend to be offered at post-graduate level, being seen as the first part of a master's degree (as well as providing the training and experience necessary to meet the national standards for qualified teacher status). This means that those entering teacher education are expected to engage with research into teaching and learning during their initial training. This is seen as important so that, from the start of their careers, new teachers see themselves as evidence-based practitioners and part of a research-informed profession. However, the one-year initial teacher training course for graduates has traditionally been an intensive and highly demanding experience, and the additional requirement to learn about research methodology and develop classroom enquiry skills places extra demands on the trainee teachers, school-based mentors and university tutors. This chapter offers a case study from within the UK experience, as an example of how effective research training can be included in teacher education courses, in ways that are integrated with the development of other professional skills.

KEY WORDS: Teaching and learning; Professionalism; Research-based practice; Classroom-based research; Teacher education and development; Research training for teachers

1 Introduction: Teaching as a research-based profession

The starting point for this chapter is an assumption that teaching *should be* an evidence-led and research-based profession: that is that teachers should be expected to both be aware of relevant research about teaching and learning, *and* to also be capable of undertaking small-scale classroom research to address professional issues and problems that arise in their work.

This assumption is based upon the nature of teaching itself. It will be argued below that given current understandings of the nature of *learning*, teaching must be seen as a profession (with the accompanying expectations and responsibilities of a profession) rather than a skilled job for which a person can simply be trained. The professional responsibilities of a teacher, consequently, cannot be understood simply in terms of acquiring 'mechanical' teaching skills, but rather need to be seen in terms of developing professional expertise through the interplay of practice, scholarship and enquiry. The present paper develops this argument, and offers as an example of what is possible, a case study describing how one University has responded provides elements of research training within the particular context of acquiring 'Qualified Teacher Status' through post-graduate study in the UK.

2 The nature of teaching

The key role of a teacher is to teach, which can be understood as meaning to facilitate learning of some target curriculum. Teaching is therefore intimately tied to notions of learning, and there is a sense that if students do *not* learn, then whatever the teacher is doing does not deserve the label of 'teaching'.

Students can learn skills (such as swimming the back stroke, or safely using a lathe), or attitudes (such as valuing learning, or desiring to make a productive and positive contribution to society), but much formal learning in schools and colleges is linked to conceptual development. So, for example, students will be asked to learn about the periodic

classification of the elements, the notion of all living things being interlinked through being part of an ecosystem, the role of the banking system in supporting entrepreneurship, the factors influencing industrial, or indeed political, revolutions and so forth.

To the lay-person, and sadly sometimes even to the teacher, teaching may be understood as the process by which a teacher's knowledge is somehow copied into learners' minds. That is, there is a 'folk' model of teaching, sometimes call the 'transfer' model, which leads to learning being discussed in terms of something sent out by the teachers which may or may not lodge in student's minds (Taber, 2009). In English, common idioms for when teaching goes wrong are that the teaching 'went over the student's head' (suggesting poor communication by the teacher) or 'went in one ear and out the other' (implying lack of ability or attention from the learner).

Yet much research into learning shows that such 'copying' or 'transferring' metaphors are woefully inadequate when discussing learning. Whilst most teachers would acknowledge this if explicitly asked, it still seems likely that the common use of 'transfer' metaphors when discussing teaching and learning plays an insidious role in underplaying the complexity of learning processes (Fox, 1983).

2.1 A constructivist view of learning

A key issue in appreciating the nature of learning, and so of teaching, is to acknowledge the nature of an individual's knowledge. Concepts (such as 'element', 'force', 'revolution', 'river', 'inflation') are abstract categories used to label perceived similarities in the phenomena of experience. However experience is necessarily a personal matter, so although concepts such as 'river' may seem to be socially shared (we can find definitions, descriptions, and lists of rivers in books), in effect we each develop our own somewhat unique personal system of concepts. We can certainly learn, to some degree at least, definitions and lists by rote, but meaningful learning that enables us to understand ideas, so that we can apply concepts, is not so easily obtained (Ausubel, 2000). In effect we all have to interpret information in terms of existing system of personal concepts, to make sense of what we see, read and are told, and attempt to integrate this new information within our current ways of thinking (Glasersfeld, 1989).

This is at the basis of the 'constructivist' perspective on learning (Taber, 2009), which posits that to some extent each individual has to construct their own knowledge of the world anew, even when books and teachers are available to considerably compress the process by supporting us in exploring the wealth of human knowledge that is already well represented in the public domain. Ultimately 'public knowledge' is really a set of negotiated representations that have been agreed as sufficiently reflecting the knowledge of other individuals, and which can only become the individual knowledge of the learner when those representations are re-interpreted within that individual's own conceptual system.

This has been convincingly demonstrated within a broad research literature in science education (Duit, 2007; Taber, 2009). Science subjects are often considered challenging, and present learning difficulties for many school pupils. Research into these difficulties has revealed that children often come to school science already holding their own alternative conceptions of science topics which are contrary to the science they are to be taught. Moreover, some of these conceptions have proved to be extremely tenacious, so that the alternative conceptions are commonly retained despite teaching directly contradicting them. Students commonly find ways of making sense of teaching in terms of their existing ideas, and by doing so fail to notice that their ideas are at odds with the teaching, even though they often severely distort the teacher's intended meaning.

Research has shown that we usually learn by making small incremental changes in our existing understanding, and so major conceptual change (such as replacing a completely incorrect way of understanding a topic by the accepted version) is difficult and rare (Chi, Slotta, & de Leeuw, 1994). The human cognitive system is very good at finding ways to make information fit with existing ideas: but much less well suited to adopting major shifts in our understanding. The latter can certainly happen – but usually only as a result over extended periods of time of extensive exposure to, and opportunities to reflect upon, the new way of thinking about the topic (Taber, 2001a). Such conceptual change is very rarely facilitated by a single lesson activity or teacher input.

Although much of the research in this area has been undertaken in science subjects, the same principles apply to all areas of conceptual learning; that is, to all 'academic' learning.

2.2 A constructivist view of teaching

This perspective on learning has a number of significant corollaries for teaching. For one thing, if teaching means facilitating learning, then providing a clear and accurate presentation of subject matter may be a *necessary but not sufficient* basis for effective teaching. This, the traditional lecture exposition, takes little account of the learners' existing level of knowledge and understanding. Effective teaching is not just an issue of 'pitching' (another transfer metaphor) at the right level to make sense to the learners, but rather designing instruction to optimally link with existing thinking, so to shift student understanding towards the target knowledge set out in the curriculum (Taber, 2001b). As research shows us that student thinking will likely include partial understandings, alternative conceptions, inappropriate links and so forth; effective teaching needs to be customised accordingly.

Moreover, as each individual comes to class with a unique personal understanding of a topic, often including some idiosyncratic notions, what is effective teaching for one member of the class may not be for another. So not only is the lecture format unlikely to be an effective way of teaching any individual about a topic in which he or she does not already have some expertise (note that lectures can be more effective ways of communicating when the audience are also experts in the subject), but any form of class teaching which is based on learning activities which are not open to being individualised for the different students is likely to be far from optimum for most of the students.

This perspective suggests that effective teaching will always be a highly interactive process, as although the teachers needs to plans lessons effectively, each lesson also needs to be optimised 'on line'; that is, teachers have to be constantly evaluating the reactions of students to teaching inputs and learning activities, and fine-tuning the lesson by making myriad real-time decisions *in situ*. Certainly teachers can gather information about learners to customise generalised lesson plans for particular classes: but those plans should only be considered outlines to

guide actions that must be selected *as the lesson proceeds* (Driver & Oldham, 1986; Leach & Scott, 2002).

The process of teaching is one of relentless problem-solving, where it is the teacher's job to identify, characterise and respond to problems, many of which cannot be predicted in advance. In this sense the teacher can be seen as having a similar role to a doctor or clinical psychologist who has to constantly apply expertise and experience to new cases, each being somewhat unique and so different from any previously treated case. Indeed, one approach to support teachers in honing their diagnostic skills in the light of the ongoing problems of matching teaching to students' existing understanding has been labelled as the 'science learning doctor approach', and offers a scheme for identifying the major types of learning 'bugs' as a first step to finding solutions (see figure 1).

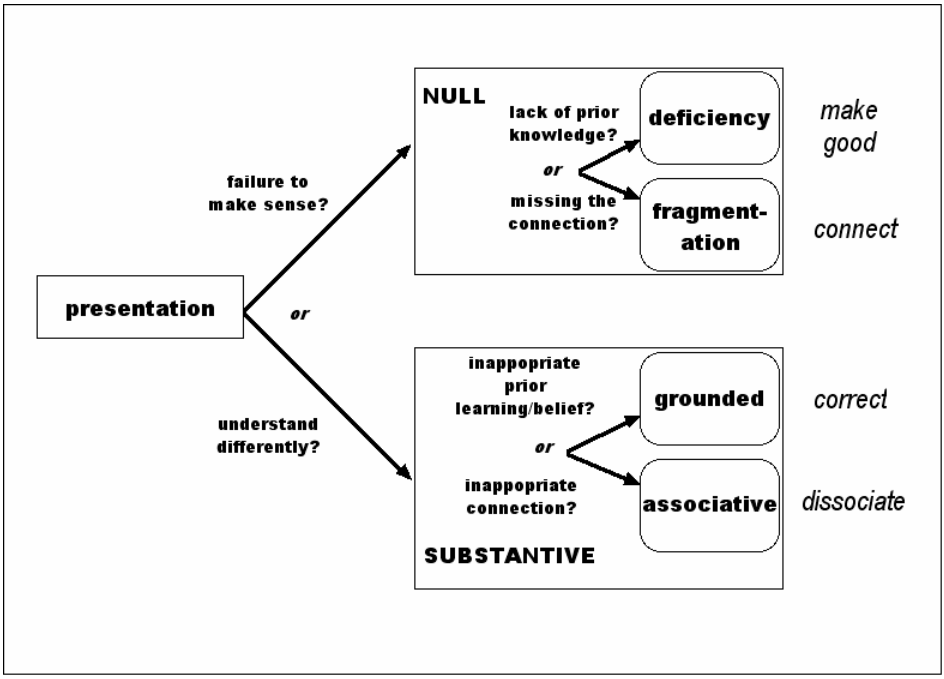


Figure 1. A scheme for identifying learning bugs (Taber, 2006b: 6)

This analysis has been based upon a consideration of the challenges of conceptual learning itself, without acknowledging other aspects of

teaching: such as resource management; behaviour management; responding to students with low confidence, limited language skills, poor motivation, short attention spans, antipathy to education etc. Such issues move the role of the teacher even further form being a matter of applying basic teaching skills through the presentation of good subject knowledge, and add further dimensions to the complex context in which teachers must constantly be diagnosing and responding to classroom issues.

3 Teacher education for effective teaching

The constructivist view of learning suggests that teaching can not be reduced to a limited number of learnable skills that could be mastered and then applied to particular teaching contexts. Rather, teachers need to be experts in professional problem-solving, who are highly informed about such matters as subject knowledge and pedagogical knowledge (Ball, Thames, & Phelps, 2008), and have developed a wide repertoire of educational techniques that they can use to build flexible and evolving strategies in response to the various unique scenarios they will meet in their day-to-day work.

Preparation for teaching through initial teacher education (ITE) courses, therefore, has to reflect this. Part of the preparation of teachers will inevitably involve learning about several areas of formal knowledge, e.g.:

- about education systems and processes;
- about teaching and learning;
- about the subject(s) to be taught;
- about subject pedagogy.

As with all learners, intending teachers will bring to learning their own idiosyncratic knowledge and understanding of education that will include areas of relative strength and weakness, as well as their own personal alternative conceptions that will distort their understanding of the target knowledge in the curriculum (Taber et al., Under review).
Moreover, such knowledge domains do not remain static. A course of ITE can only provide support in learning about the current best available knowledge: and that knowledge will often not remain the best

available during a teaching career that will hopefully extend over several decades at least. So teachers have to be keen and effective life-long learners.

In addition, intending teachers will need to develop their 'practical' skills by applying such knowledge as pat of authentic teaching experiences, which will enable them to convert formal academic learning into practical craft knowledge that can readily be applied in real teaching contexts.

Combining both these aspects within a single course of ITE has always been a challenge, and it is widely acknowledged that no matter how strong the preparation, the realities of the first teaching post will challenge most new teachers. This is now officially recognised in the UK system, where the first year of teaching post-ITE is now supported by special monitoring, mentoring and evaluation arrangements (Department for Children Schools and Families, 2008).

However, the understanding of effective teachers as professionals engaged in constant and on-going problem-solving adds an additional component to be considered in teacher education programmes: no ITE course could ever provide its students with a toolbox of ready solutions for *all* the professional problems they will meet. Instead, new teachers must be prepared to enter the teaching force aware that they will not be equipped to with solutions to all the challenges they face, but confident they have been prepared *to develop* suitable solutions.

In effect this means that those passing out of qualifying courses for teaching must have developed appropriate attitudes and skills to undertake effective enquiry in support of solving professional problems. This is clearly related to the need to be a life-long learner, but goes *beyond* an ability to keep 'updated' with the latest subject developments, or new pedagogies, or curriculum and assessment innovations etc. That may *sometimes* be sufficient to support effective professional problems-solving, but often it can only offer possibilities, and it is not enough for the teacher to simply adopt and apply new knowledge without regard to the specific individual teaching context. If this seems abstract, it can be illustrated with some examples.

One aspect of official guidance on pedagogy which was widely recommended to teachers in England during the first decade of the current century was the 'three part lesson'. This was a general lesson structure, suggesting that lessons would normally commence with a short 'starter' activity to engage students and to review key learning for a previous lesson or act to introduce the theme of the new lesson. This would precede the main lesson segment where key teaching and learning of the topic would occur. Then the lesson would be concluded with some kind of plenary activity that reviewed key learning in the lesson. The lack of flexibility in this approach has been rightly criticised (Advisory Committee on Mathematics Education, 2006).

Another idea that has been very popular in many UK schools is the notion of learning styles. There are actually a range of models of learning styles which describe how different students have preferences about how best to study. Some of these models are supported by bodies of research, but other approaches seem to be based largely on anecdotal evidence (Coffield, Moseley, Hall, & Ecclestone, 2004). So one popular (and simplistic) approach seeks to find which students primarily learn through verbal, visual or kinaesthetic models, and then offers a choices of learning activities to mach these different preferences. This model draws heavily on Gardner's model of multiple intelligences (Gardner, 1993), but seems to have limited support as a scientific account of student learning styles.

These are just two examples of the many ideas that may be proposed as ways to teach well, and which teachers may be exposed to. Now we can consider a range of responses of teachers to such 'innovations'.

4 A typology of teacher professionalism

To keep things simple, we can consider four basic levels of teacher response, which I will caricature as:

- Level 0: the trained worker
- Level 1: the technician-professional
- Level 2: the scholarly professional
- Level 3: the researching professional

I have labelled the first level, the trained worker, at level 0, because I do not consider this a 'professional' level of response. The trained worker has employment as a teacher, and feels sufficiently competent to hold down their post. The trained worker considers they are already trained for their work and will avoid engaging with any innovations (which will usually require extra work and effort) if possible. Most of us have come across some teachers who seem to take this stance, but in many education systems they are rare. Such people do not see themselves as needing to be life-long learners at work, and ideally should not be working in education.

The next level comprises of those who see their roles within the education system as more like technicians than fully professional practitioners. These individuals recognise that their teaching can always be improved, and they are generally happy to embrace change. However, they do not see it as their role to set out what those changes will be. They do not seek innovations, but are quite happy to cooperate in any innovations that are recommended by government, school boards, principals, heads of faculty and so forth. They take pride in implementing such changes but do not see it as their place to instigate or evaluate them. The general attitude towards improvement is to be welcomed, but again these teachers fall short of being fully professional. Given the wide range of contexts in which teachers work (different ages groups; different teaching subjects; classes of different ranges and levels of aptitude, ability and motivation; different levels of resources; different teaching personalities and styles, etc) it is likely that few specific innovations can bring improvements across a broad swathe of teaching and learning contexts – certainly without some degree of customisation and individual modification.

This will be appreciated by those teachers working at the next level, as they will bring an intellectual quality of criticism to all new innovations that are recommended. That is not to say that they will be cynical and necessarily take a negative posture to such suggested changes. Rather they will not assume that the recommendations of authorities are *necessarily* going to work in *their* classrooms, with *their* classes. They will seek the latest research and thinking about teaching and learning their subject, and they will read widely beyond the official accounts presented in government teaching guidance and policy documents. This will

enable them to make more professional decisions about which suggestions should be wholeheartedly endorsed, which should be tentatively welcomed, and which should - in all conscious - be gently resisted.

However, there remains a fundamental problem with this position, even if it is more enlightened than our earlier categories of teacher response. Teaching and learning are complex phenomena, and vary considerably. Research tends to be carried out in particular contexts – usually within single education systems, often with limited age ranges, and in some cases in a single school or even a particular classroom. Where there are a number of related studies exploring similar innovations in different contexts, the effectiveness often varies considerably from one school or teacher to the next. Often there are too many possibly relevant variables to control in research, and indeed often the contexts are not described in sufficient detail in reports for effective 'reader generalisation': that is, for the reader to make a decision about whether a study context is likely to be sufficiently similar to his or hr own teaching context for the study findings to be relevant there (Kvale, 1996).

Therefore scholarship is informative, but often does not do more than suggest what *might* 'work here'. The fully professional teacher therefore has to be capable and sufficiently confident in their research skills to undertake classroom based enquiry that can effectively try out and evaluate the effectiveness of new ideas in his or her own classroom (see figure 2). These teachers will not simply adopt a three-part lesson, or a simple model of teaching styles: they will read around the topic, and then decide whether it is worth trialling the ideas in their own teaching with a view to adaptation and adoption.

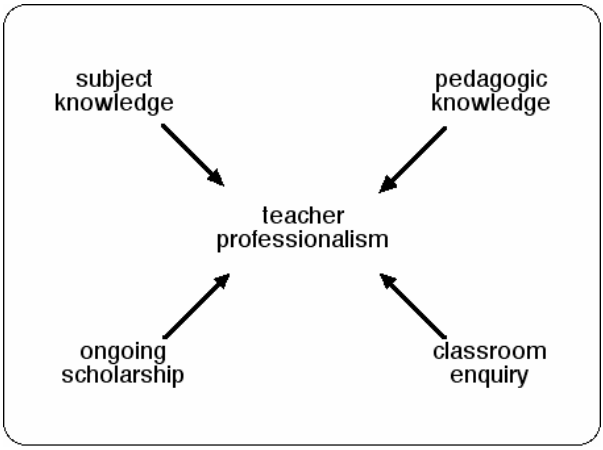


Figure 2. Pillars of teachers' professional knowledge

Furthermore, this analysis only considers the 'reactive' aspects of teacher professionalism: how teachers respond to recommendations that they should change their practice. The essence of the teacher as professional problem-solver is to recognise issues and problems in their own teaching, and to find solutions which solve those problems and improve teaching and learning (Carr & Kemmis, 1986). The technician-professional may recognise problems, but will seek out the general approach recommended as a solution according to current guidance or recommendations on best practice. The scholarly professional will again go beyond that by seeking out, critically interrogating and comparing at a range of sources, including where accessible actual research (Taber, Accepted for publication), but will still be limited to adopting what his or her reading suggests is the best available approach. Again our researching professional will be empowered to go further by testing out and modifying approaches through cycles of carefully evaluated action research in his or her own classroom (see Table 1).

Table 1. Levels of teacher professionalism in terms of attitudes to developing practice

level	reactive characteristic	proactive characteristic
0	avoid recommended innovation	does not seek change
1	adopts recommended innovation	seeks recommended solutions to perceived problems
2	critically evaluates recommended innovations by wide reading	critically reviews wide ranging sources to select preferred approaches to perceived problems and issues
3	critically evaluates recommended innovations by wide reading and classroom testing	critically reviews wide ranging sources to inform action research to develop solutions to perceived problems and issues

5 Exploring a nested case study of ITE

It was suggested above that teaching and learning are highly complex phenomena, such that findings from one specific educational context cannot be readily assumed to be generalisable across other contexts. Educational studies therefore need to address issues of context (Taber, 2008). In some cases this means posing research questions in specific terms – stating that a study refers to a certain age group, in a certain type of school within a particular national or regional education system – whereas other studies look to be more inclusive, but must therefore include representative samples that are considered to encompass the variation along those dimensions considered significant to the study. Research resources are inevitably limited, so although surveys may collect data from a much wider base, they are usually limited to confirmatory studies, where precise questions and response categories can be fixed at the start of the study. Often, in education, our work is at a much more exploratory stage, where more open-ended in-depth work is needed, and where surveys are not helpful (NRC, 2002).

At the other ends of the scale is the case study, where a study limits itself to a single instance, but in doing so focuses the full resources of the enquiry on that case, and seeks to report it in sufficient detail to support

the 'reader generalisation' referred to earlier (Yin, 2003). That is, case studies should provide sufficient detail for a reader working outside the case to feel informed enough to answer the question: is the context of this study sufficiently similar to my own professional context that the findings may be relevant to my own context? So when a case account reports an effective educational innovation, a reader is able to consider the questions: 'is that likely to work here?' (Taber, 2007a)

The present chapter considers a form of educational innovation designed to address a perceived educational issue. The issue (as discussed above) is the need for fully professional teachers to be confident and resourced to undertake classroom enquiry to address problems and issues they identify in their professional work. The innovation is the inclusion of basic research training within ITE, which is the approach that has been taken to address this issue in the author's own University. This specific teacher education context will therefore be discussed as a case study. The case will be addressed in a 'nested' fashion (see figure 3). The wider National context of teacher education in England will be briefly introduced, and then the specific PGCE (Post-Graduate Certificate of Education) qualification will be discussed. The account will then focus on the course leading to the award of the PGCE for secondary teachers at the University of Cambridge, with particular emphasis on the incorporation of research training into the course in recent years. Although the space available necessarily limits the detail that can be included, the intention is to offer sufficient context and detail for readers in other educational contexts, who recognise the challenge of preparing teachers to be researching professionals, to consider whether the approach discussed here might be drawn upon in their own professional contexts.

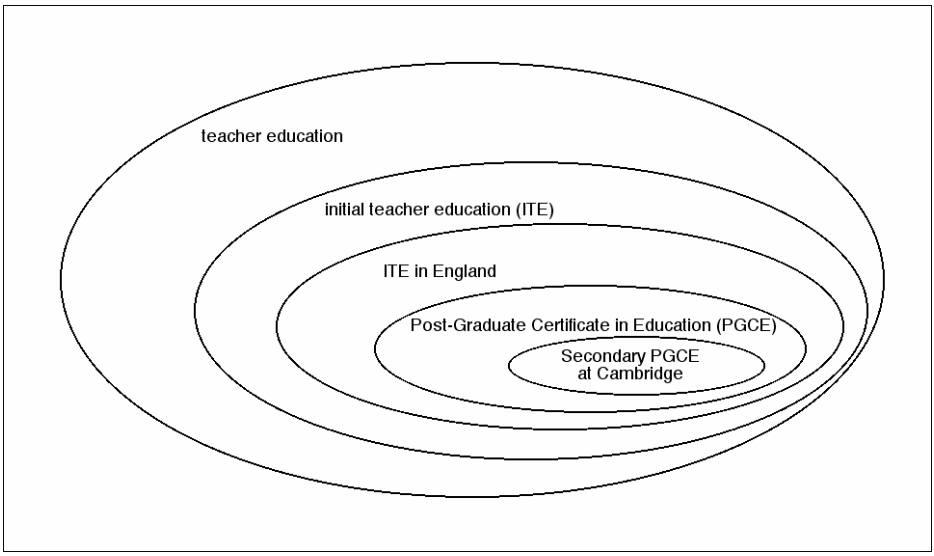


Figure 3. The nested case study

6 A case study of ITE for preparing teachers who are researching professionals

I will here consider, then, the approach to developing researching professionals on the ITE course at the University of Cambridge in the UK. In particular, I will discuss the programme for those training to be secondary phase teachers (of 11-18 year olds). Some specific examples illustrating the general principles will be drawn from work with trainee science teachers.

6.1 The wider context of the case

Teacher education can be divided into two main phases, referred to in the UK as initial teacher education (ITE) and continuing professional development (CPD). ITE refers to the courses that intending teachers study before being considered as qualified teachers, and CPD refers to the various professional activities (including, but not limited to attending courses) that teachers undertake after qualification to update and develop their professional work. It is clear from the discussion above, then, that the type of scholarship and classroom enquiry

considered characteristic of fully professional teachers would be considered CPD activities; and therefore part of the task of those charged with facilitating ITE is to provide new teachers with the right mind-set, confidence levels, and skills for them to both see scholarship and classroom enquiry as part of the teacher's work, and to have the capability to actively engage in these activities.

In England, the educational context of the case discussed here, teachers are awarded Qualified Teacher Status (QTS) by the government department charged with education, and are required to register with the professional body, the General Teaching Council for England (GTC). QTS is awarded based on assessment of new teachers against a set of teaching 'standards', again set by the government. Of particular relevance to present concerns, before qualifying as teachers, trainees must demonstrate (TDA, 2007: 6), *inter alia*, that they

- can "reflect on and improve their practice, and take responsibility for identifying and meeting their developing professional needs";
- are able to "identify priorities for their early professional development …"; and
- "have a creative and constructively critical approach towards innovation, being prepared to adapt their practice where benefits and improvements are identified".

There are various possible routes to acquiring QTS for an intending teaching, including in some cases being employed as a supervised unqualified teacher in a school, and assessed in post (British Council, 2005). However, the most common route is for students to enrol on courses of ITE provided by higher education institutions, i.e. mostly universities. The main ITE route in universities, and especially for those wishing to teach at secondary level where they will be subject specialists, is the Post-Graduate Certificate in Education (PGCE).

6.2 The secondary partnership PGCE course at Cambridge

The PGCE is a one-year course of ITE for graduates. The PGCE course for intending secondary students runs over 36 weeks, of which two thirds of the time is to be spent in schools.

The University of Cambridge offers PGCE places in most secondary curriculum subjects. Applicants are usually expected to have a first degree in their teaching subject or a closely related subject (e.g. engineering to teach science) with a high classification (first or upper second class honours), and some recent experience of, at least, observing lessons in state secondary schools. In practice many applicants have higher degrees (masters or doctorates), and many have experience of working with school age youngsters – for example as learning assistants (teacher's assistants) in schools or as volunteers in youth organisations. Indeed many applicants for the Cambridge course have experience of teaching overseas (during Summer projects or 'gap-years'), and many have taken part in outreach activities when students: for example regularly visiting schools to support projects or after-school clubs. As the PGCE is a master's level academic qualification and also a programme of professional preparation for teaching, it is considered essential that at interview candidates can demonstrate both potential for successful post-graduate study and a strong aptitude to work with school age learners.

During the one year course, students are simultaneously assessed against both the academic expectations of the University's PGCE award, and the government's QTS standards. The course is taught and assessed as a partnership between the university and local schools, with both Faculty members and school staff taking central roles in the process. This general approach was initially developed at Oxford University (McIntyre & Hagger, 1992). Students spend time in (at least) two secondary schools during the course. These are partner schools involved in the planning and delivery of the course, with key school teaching staff prepared for their roles by the partnership. Each school has a senior member of staff who oversees the ITE work in the school, and each student ('trainee') is assigned to a subject department and a particular subject specialist to act as mentor. The school's staff take a leading role in inducting the student into the practicalities of teaching, and trainees are gradually given increasing responsibility for planning, teaching and evaluating classes under careful but increasingly hands-off supervision of the more experienced staff who work permanently in that school context.

As well as being assessed on school placement against the government's standards for QTS, the student teachers must also complete written PGCE assignments for formal assessment by the University. These are academic assignments which are ground in the students' on-going professional work in the schools.

6.3 Introducing research training into ITE

During a one-year ITE course the Faculty can support learning about current best thinking in education, and in particular in relation to subject pedagogy. However, such information becomes out of date quickly: thus the need to prepare teachers to develop habits of scholarship to support future CPD.

During their school placements, school-based mentors are well placed to help the student teachers learn how to apply their professional knowledge in relation to real life teaching contexts. However, again, all schools are different, all classes are to some extent different, and over time teaching contexts shift. So the PGCE has to prepare new teachers to be able to effectively find out about, try out, and evaluate potential solutions to new professional problems they may identify in their teaching. The *specific solutions* may or may not be useful to them later in their career as they work in new schools, with new classes. However, *the ability to undertake such classroom based enquiry* transfers to all future teaching contexts.

The Cambridge partnership PGCE has therefore since 2005 formally incorporated basic aspects of research training in the PGCE (formally, as elements of such training have long been an implicit part of the course). This includes learning about the range of types of research that can inform education, their relative strengths and weaknesses, and the ability to critically evaluate published studies (Taber, 2007a). It also includes learning how to carry out small scale classroom based enquiries.

These research foci are built into the academic assessment on the course. First term assignments which are assessed in formative mode (modelling good practice to the new teachers) ask students to collect data in various ways, linked to their reading of relevant research literature. For example, students preparing to be science teachers are

asked to read about students' alternative conceptions in a topic one of their classes will be studying, and to undertake some diagnostic assessment to inform the planning of possible lesson. They are also asked to observe and collect examples of language used in the science classroom (e.g. teacher questions, small group dialogue, samples of textbook material) and to analyse this in terms of established ideas in the literature. Although students are given guidance, they are free to chose their focus, and identify research literature to inform their work.

In the second term, students undertake an examined assignment on a whole school issue which takes the form of a critical review of literature. Students are expected to discuss a small range of studies on a topic (for example, the practice of setting – assigning students to classes according to their attainment), considered the strengths and weaknesses of the different methodologies employed in the studies. In their final term, students carry out and report a small scale enquiry into some aspects of teaching and learning in one of the classes they themselves are teaching. The study is expected to have a clear focus and/or research question, a review of relevant literature, a justified methodology, an analysis of relevant evidence, and a discussion of findings that acknowledged limitations in the study and relates conclusions back to the literature.

Students are free to choose an approach, but are recommended to consider either undertaking a cycle of action research to address a professional issue they have identified with a class, or to undertake a case study of some aspect of teaching and learning they find particularly interesting (see Figure 4).

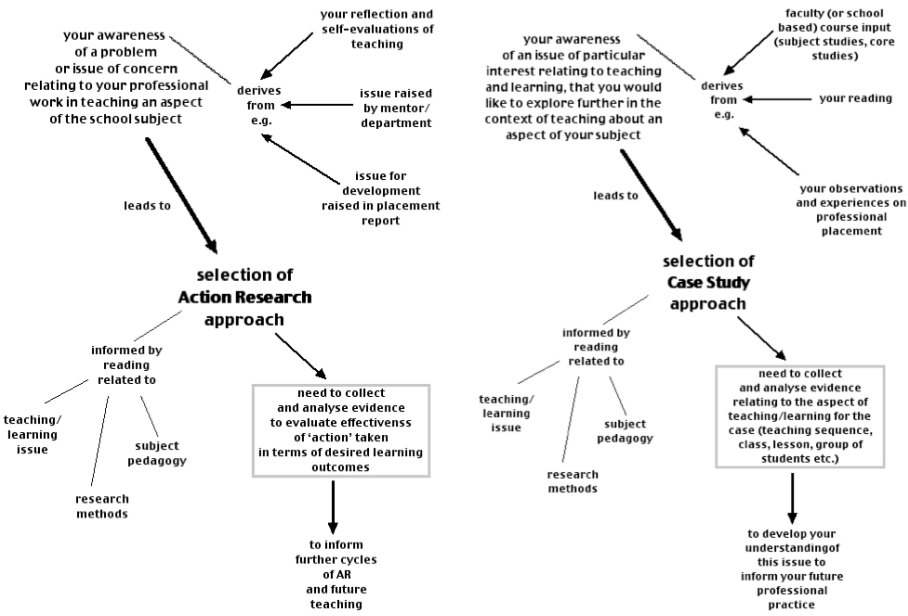


Figure 4. Two approaches for a student teacher's study-in-depth

The students are encouraged to pick a classroom issue that they find of particular interest, and to liaise with their school based mentor and other members of the host department who can offer support in the project.

These studies are inherently empirical, and data can be collected by observations, interviewing, questionnaires etc, as well as including records of students' classroom work (such as photocopies of student writing, recordings of classroom discussions, photographs of student posters or models, video recording of role play work and so forth). The text box presents as examples a small selection of study titles from students training to be science teachers:

A critical analysis of teacher questioning techniques to promote spontaneous participation.
A case study of students with English language difficulties in science classes.
A comparison of progression in learning of two year ten classes of different ability studying waves and radiation.
A critical analysis of a set of resources for teaching the sound and hearing module for Year 8 to extend gifted children
The use of the notion of cognitive layers in the process of teaching electrical circuits
Teaching and learning styles in a class of AS Level Physics students studying quantum mechanics?
Do Analogies Aid Students Understanding of Electrical Circuits?
How kinaesthetic teaching strategies can enhance interest and learning of geology modules for a high ability year 8 group.
The impact of interactive whiteboards and associated technology on motivation and enjoyment within the teaching of year eight microbes and year seven electricity
The Big Bang and God: A case study of the range of beliefs and ideas about the origins of the universe among the students in one Y10 class, and a critical evaluation of the implications for science teaching.
The use of animalistic and anthropomorphic analogies in the teaching of the Year 10 "Metals" topic.

Test box. Some examples of titles for student teachers' 'study-in-depth' assignments

6.4 Supporting student teachers in learning about educational research

Much of the faculty-based study on the PGCE course is based in teaching subject groups, so although some aspects of the support for learning about educational research is at a course level, much is integrated into the sessions devoted to developing understanding of teaching and learning within the subject. This allows the students to be taught about research in the context of reading, critiquing, and learning from the literature in their own areas: history education, geography education, mathematics education, and so forth. This ensures that students are able to appreciate the motivation behind and relevance of

the research they read, and see how it could inform their own classroom practice (Counsell, Evans, McIntyre, & Raffan, 2000).

The students are provided centrally with a detailed guidance document on planning, executing and reporting their study-in-depth. Moreover, an introduction to educational research written with this particular group of learners in mind is included among the recommended reading and is available through the Faculty Library as an ebook. This text, *Classroom-based Research and Evidence-based Practice: a guide for teachers* (Taber, 2007a) was designed to help teachers new to research understand basic principles, and learn how to plan and report classroom enquiry, drawing heavily upon critiqued examples of published educational research.

Faculty members working with groups of student teachers can build into their schedules opportunities to develop practical research skills into their programmes: as in the work for the term 1 assignments, considered above. Some examples of research-based activities undertaken by some of the trainee science teachers have included:

- undertaking a survey of student understanding of key science terms in local secondary schools (Taber, 2006a);
- undertaking case studies of teaching about ideas and evidence in science, as part of a national initiative (Taber et al., 2006);
- working as teaching/research assistants on a project to provide enrichment activities for local school children (Taber, 2007b);
- helping to plan and run a 'challenging science day' for students from local schools visiting the University (see http://people.pwf.cam.ac.uk/kst24/ChallengingScience/Site/Introduction.html)

7 Conclusions

The inclusion of explicit research training as a significant component of an ITE programme is still a fairly recent development. As the ultimate aim is to develop fully professional teachers to have the necessary attitude, skills and competences to be users of educational research and producers of classroom enquiry throughout their careers, the eventual success of this innovation cannot be judged for some decades.

However, there are some clear indicators that this has been a valuable development, which has enhanced student teachers' preparation for the challenging and vital role of classroom teacher. Students themselves seem to generally appreciate the opportunity to undertake an in-depth empirical study, and much of the work produced is of an impressive standard. This has been recognised within the University in terms of progression to a Master's degree, and through some student work being published for the benefit of other teachers.

In terms of progression, the University of Cambridge now considers its PGCE to be worth 0.5 credit towards the 2 year, part-time MEd (Master of Education) degree. That is, successful students can be admitted by direct entry to the second (final) year of the MEd. During that year, students must produce a 20 000 word research based thesis. The Faculty has introduced two specific routes primarily for students progressing from the PGCE (MEd: Researching Practice 5-18 (Primary and Secondary Schools); MEd: Science Teacher Researchers and Practitioners), although students are also entitled to apply for entry to year 2 of other MEd routes. Members of the Faculty of Education have collaborated to produce a text book designed to support students making this progression (Wilson, 2009).

Figure 5 shows how the learning experiences during the ITE (PGCE) course provide the basic research training to prepare the candidate for the final year of the MEd.

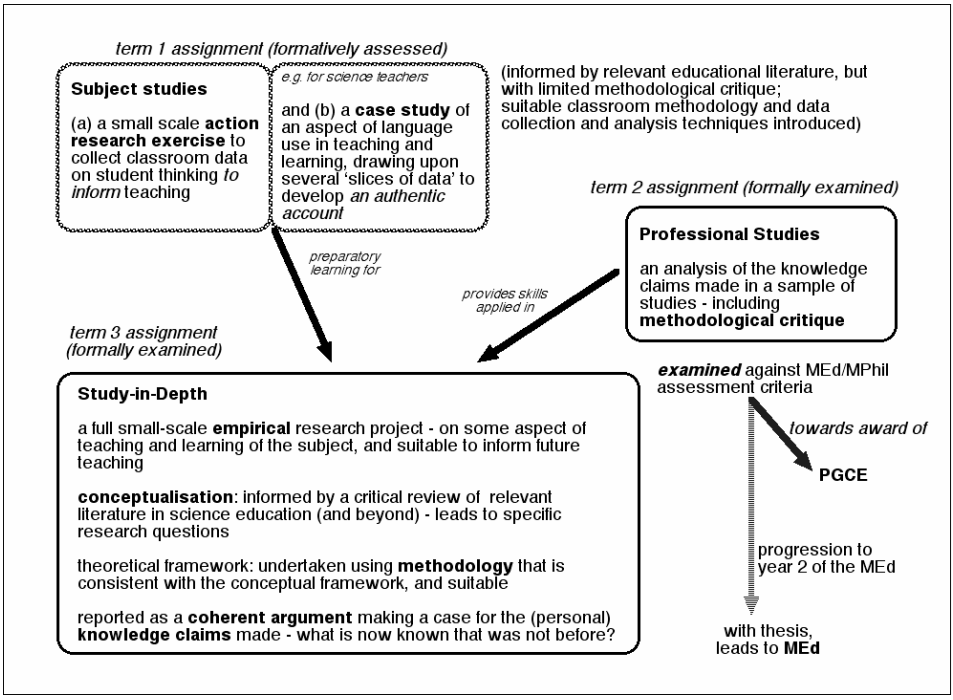


Figure 5. Preparation during the one year PGCE for entry to the second year of a thesis based part-time MEd degree

This new progression route has now produced its first MEd graduates, and it has been found that not only are PGCE students quite able to produce ITE assignments which meet the Master's assessment criteria, but those students admitted directly to year 2 of the MEd from the PGCE generally do at least as well as other (two year) MEd students.

The other point made above is that some work produced by PGCE students for their studies-in-depth are of sufficient quality to offer insights of value far beyond their original teaching context. Sometimes this has been demonstrated by students writing-up their studies for publication in professional journals (Brock, 2007; Styles, 2003). However, most students completing their PGCE courses then move immediately into their first full-time teaching post, and – understandably – this tends to take priority over finding time to submit their work to journals.
Consequently, the Faculty of Education is in the process of starting its own on-line, open-access, journal to publish student work – the *Journal*

of Trainee Teacher Educational Research, JoTTER (http://jotter.educ.cam.ac.uk/). The first volume is being compiled at the time of writing from student studies submitted by 2009 graduates from the PGCE course. JoTTER will provide trainee teachers with public acknowledgement of the quality of their work whilst demonstrating that they should indeed be recognised as well on their way to being fully professional teachers able to integrate scholarship and enquiry into their classroom work (see figure 6).

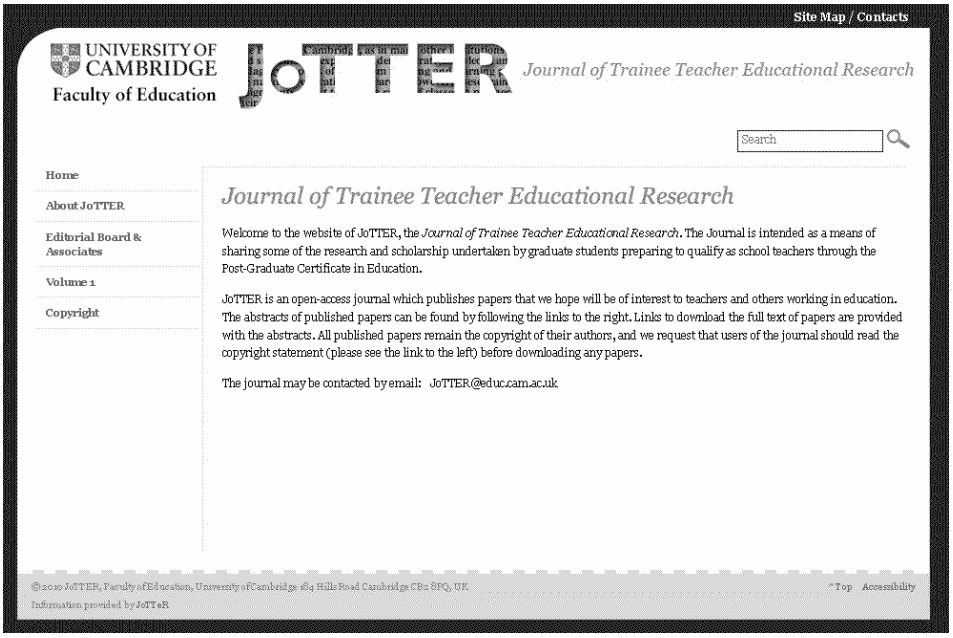


Figure 6: A website to publish student teachers' research

This chapter has discussed the issue of supporting the development of research skills as part of ITE. The theme has been illustrated by a case study reporting the innovative approach being taken in one Faculty of Education. Case studies are useful when a focus is part of a complex situation where it is impossible to separate the phenomena of interest from their context. Learning to teach is certainly a complex matter, and it is not appropriate to assume that the approach taken in this case could unproblematically be transferred to other contexts. The context of preparing teachers in England will be somewhat similar to, and yet also

significantly different to, that in other education systems. Even within England, courses in different Universities will vary. Cambridge is the second oldest University in England, and is widely recognised as one of the World's most prestigious Universities. ITE at Cambridge has been repeatedly graded as excellent by government inspectors, and the Faculty regularly features at the top of 'league tables' for both teaching and research in education in the UK. Cambridge is not 'typical', but then it is not the purpose of case studies to represent what is necessarily typical.

However this case does show that, under the right circumstances, elements of research training can effectively be included in ITE. In this way, it offers an example of what is possible, and therefore suggests what it may be reasonable for other institutions to consider. The precise approach reported here may not work everywhere. However, if it is considered important to provide new teachers with the full range of professional skills needed to effectively respond to the challenges they will face in their teaching careers, then ITE *in all contexts* should be understood as preparing teachers to join a research-based profession.

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FOSTERING STUDENTS' LEARNING WITH STUDY GUIDES:

The Relationship with Students' Perception and Learning Patterns

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SUMMARY

Research on students' use and perception of study guides in higher education is scarce. In a quantitative exploratory study, students' perception of study guides and the relation between their perception and their learning patterns were analysed. Sixty-nine first-year students participated in this study. Results showed that the overall perception of students of study guides is positive. Study guides are consulted frequently and intensively. They are primarily considered as instruments to provide information and clarification. Moreover, students' perception is positive when a more frequent and intensive use of this instrument by faculty is reported. Finally, students who perceive study guides positively, appear to be highly analytical learners, and self-regulated or externally regulated learners.

KEY WORDS: Study guide, Higher education, Student perception, Learning patterns, Learning styles, Self-regulated learning

1 Introduction

Expectations towards students in higher education have changed over time. Learning cannot be considered as a passive knowledge-consuming process anymore. Students are expected to be more autonomous and more self-regulated in their learning (Boekaerts, 2006). They have to be prepared to be lifelong learners. In order to foster the development of these competences on a student level, learning environments and teaching approaches in higher education need to be supportive in this respect. Students gradually have to be provided with more freedom in their learning process (Vermunt & Verloop, 1999). Because of these changing demands, there has been an evolution towards supporting open and self-regulated learning in higher education. At the beginning of a course module it appears to be important to inform students about the objectives, the assessment, the possibilities of support and the sources of information. Within the freedom of their learning process, students need an aid/support that provides clarity to them and that increases the possibility of self-regulated learning (SRL). An instrument that faculty can use to provide this kind of support for their students is the study guide.

Previous research on the use of study guides in higher education is scarce (Van Petegem, Di Perna, Donche, Goegebeur, Van Looy & Vernaillen, 2004). In several institutions in higher education the use of study guides is becoming mandatory with regard to innovation policies concerning competence-based and student-centred education. Since little is known about the use of study guides, many faculty members are asking themselves whether all the time and energy that they invest in designing study guides is worthwhile. Do students actually use their study guides and if so, do they use them more than once? What do students think about study guides? Both research and practice might therefore benefit from a more in depth exploration of students' perception of study guides.

2 Theoretical framework

2.1 The growing need for self-regulated learning

Students are expected to become lifelong learners. Therefore they need certain skills, such as active knowledge construction and self-regulation (Masui & De Corte, 1999). Self-regulated learning implies an enhanced attention for autonomous learning. Responsibilities for learning increasingly shift from faculty to students when compared to a traditional learning environment. The student is actively involved in his or her own learning process. To realize increasing freedom and autonomy for students, it is important to create, on the one hand, a learning environment that anticipates their need for freedom, and on the other hand takes into account their need for transparency about, amongst others, the learning objectives and assessment. This teaches students to cope with increasing degrees of freedom. Autonomy support, however, does not mean that students should be left to fend for themselves. They also need clarity. Faculty can provide transparency about the students' freedom and responsibilities, thereby facilitating self-regulated learning and making the learning environment more powerful. They can also provide transparency about the possibilities of support in the learning process. A tool that serves to guide students in self-regulated learning is a study guide.

2.2 Study guides

2.2.1 Description

Opinions about the description or definition of study guides tend to differ. Variation in terms ('course syllabus', 'course description' etc.), descriptions and definitions can be explained by the fact that 'study guide' is an umbrella term (Grunert O'Brien, Millis & Cohen, 2008; Van Petegem et al., 2004). In this study we opt for the rather broad definition that is given to faculty at the University of Antwerp:

> *"A study guide is a printed and/or digital document that faculty use to give students information and clarity about the learning environment and with which they support them in actively processing the learning content. In literature a study guide is described as a whole of guide lines and as a means to stimulate students actively and autonomously at working with the learning content and the study material."* (Donche & Van Petegem, 2002)

2.2.2 Three functions

Generally speaking, three functions of study guides can be discerned (Van Petegem et al., 2004). A study guide can be seen as an information instrument, as a support instrument, and as a learning instrument.

The first function of a study guide is that of information instrument. The study guide informs students with respect to content and didactical aspects of the learning environment. With the study guide, faculty can inform their students of arrangements, assignments and other aspects of the learning process. Since students ought to be given more freedom and responsibility, it is essential to decide on clear arrangements about the roles of the student as well as of faculty. This supports an optimal use of the students' freedom and responsibility. Clarity and transparency in learning environments stimulate self-regulated learning. The information that faculty give their students by means of the study guide is sometimes considered binding. Research shows that faculty often regard their study guides as a contract between themselves and their students.

The second function of study guides is that of a support instrument. Faculty can use study guides to hand their students organisational and strategic support in their self-regulated learning. In this way they can (indirectly) guide and support their students.

A third function of study guides is that they are a tool to actively put students to work with the learning content. Study guides stimulate students to planning their learning process by providing planners sketching the workload. They are supposed to help students achieve the learning objectives by adopting their own learning strategy. Faculty have to make sure that their study guides do not become a document in which students are told stepwise what to do.

2.3 Learning patterns

Over the last few decades, a lot of research effort has been invested in exploring how students learn in higher education and what factors influence these processes. This research stems from a variety of research traditions (Entwistle & McCune, 2004) and has evolved in different directions. A shared feature of many of these studies is the search for

links between various cognitive, meta-cognitive and motivational/affect dimensions of learning and construct more integrated learning (style) models (e.g. Jonassen and Grabowski 1993; Donche & Van Petegem; 2009).

In his original framework Jan Vermunt introduced the notion of 'learning style' (1996) as an attempt to provide a more comprehensive account of learning by bringing together four different aspects of learning, namely: cognitive processing strategies, regulation strategies, conceptions of learning, and orientations to learning. He devised the inventory of learning Styles (ILS) as an instrument to map these learning components (Vermunt, 1998; Vermunt & Vermetten, 2004).

Each of the learning components in the model is comprised out of several learning dimensions as is shown in table 1. *Cognitive processing strategies* refer to the cognitive thinking activities students apply to process subject matter (Vermunt, 1998). Vermunt discerns three main cognitive processing strategies: deep processing, stepwise processing and concrete processing. *Regulation strategies* are those activities that students use to steer their cognitive activities. Depending on the 'source' students use to regulate their learning, Vermunt distinguishes between self-regulation, external regulation and lack of regulation (Vermunt & Vermetten, 2004). *Learning conceptions* denote students' knowledge and belief-systems about learning and studying. Finally, building on the construct as introduced by Gibbs and colleagues (1984), Vermunt regards *learning orientations* as the whole of students' personal, goals, intentions, motives, expectations concerns and doubts with regards to their studying. Based on factor analysis Vermunt identified four learning styles that integrate dimensions from the above described learning components: an undirected style, a reproduction-directed style, a meaning-directed style and an application-directed style (see table 1).
According to the Vermunt-model, students on the one hand have general preferences in learning, while, on the other hand, it acknowledges that the ways students learn are liable to factors in the educational context (Vermunt, 2005). To make their viewpoints on the modifiability of learning more explicit, Vermunt and his colleagues therefore began to use the term 'learning patterns' instead of 'learning styles' (Vermunt & Minnaert, 2003; Vermunt & Vermetten, 2004). As we

share this view, the term learning patterns will be used throughout this chapter.

Table 1. Learning components, learning dimensions and learning patterns (based on Vermunt & Vermetten, 2004).

	Meaning-directed	Reproduction-directed	Application-directed	Undirected
Cognitive processing strategies	Deep processing – Relating & structuring – Critical processing	Stepwise processing – Analyzing – Memorizing	Concrete processing	Little processing activities
Regulation strategies	Self-regulation	External regulation	Self-/ External regulation	Lack of regulation
Learning orientations	Personal interest	Self-test oriented Certificate oriented	Vocation oriented	Ambivalent
Conceptions of learning	Construction of knowledge	Intake of knowledge	Use of knowledge	Cooperative learning Stimulating education

Some authors have adapted the initial learning pattern model, by substituting the learning orientation scales with scales based on contemporary motivational frameworks such as Goal theory (Vermetten, Lodewijks & Vermunt, 2001) or Self-determination theory (Donche & Van Petegem, 2009). This theory has sought to further refine the traditional distinction between intrinsic an extrinsic motivation by introducing a multidimensional view on motivation (Ryan & Deci, 2000). It distinguishes between both the quantitative and the qualitative dimensions of motivation (see also Figure 1).

The quantitative dimension of motivation is concretized in the concept of *amotivation,* or lack of motivation. Amotivated students are apathic and have little concern for their studies. They will exhibit very few learning activities and when they do they seem to lack the ability to regulate their study behaviour and predominantly make use of surface strategies.

Regarding the quality of motivation, self-determination theory elaborates on the traditional difference between extrinsic and intrinsic motivation by dividing extrinsic motivation in three sub-types of motivational regulation.

Students who are *externally regulated* are driven by an external pressure such as external rewards, expectancies from others or the avoidance of punishment. This type of regulation is most closely associated with the traditional view of extrinsic motivation. However, according to SDT, pressure does not necessarily have to originate from outside the students. In *introjected regulation* students experience these obligations from inside. Their learning behaviour is motivated by feelings of pride, guilt, fear of failure or shame. Because in both aforementioned types of motivation, students do not freely choose to engage in learning activities but rather are pressured into action, they are sometimes combined in the overarching concept of *controlled motivation*.

Besides two types of controlled motivation, SDT introduces a third form of extrinsic motivation, called *identified regulation*. Here students engage in learning activities because they attach a personal value the learning activity to it or because they recognize the relevance of this study behaviour in view of their later occupation. Although not intrinsically motivated, students will regard these learning activities as a personal choice instead of a pressure and experience psychological freedom when studying. This is also the case for students who are *intrinsically motivated* and engage in learning activities for its' own sake As both identified motivation and intrinsic motivation can be characterized by feelings of choice and personal freedom, they can be conceptually combined in the concept of *autonomous motivation*.

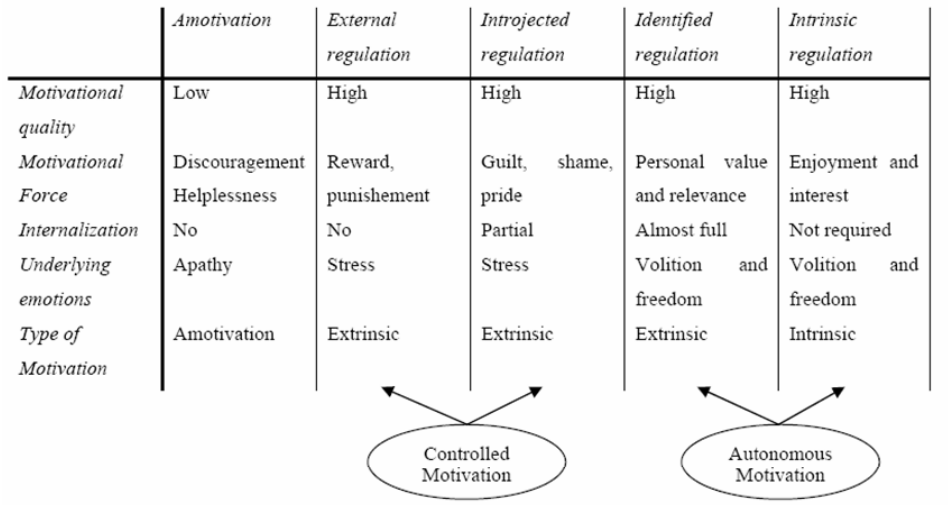


Figure 1. Dimensions of motivation according to Self-determination theory

Research has shown that the difference between autonomous and controlled types of motivation is more valuable in explaining students' learning activities and outcomes than the traditional intrinsic-extrinsic distinction. Students who are autonomously motivated persist longer, are better in organising their learning activities, are better concentrated, engage in deep learning, achieve higher grades and feel better than students who are driven by controlled motivation (Vansteenkiste et al., 2009).

2.4 The importance of students' perception

Whether students' learning patterns or their motivation is related to the use of study guides or students' perceptions of the value of this instrument remains unclear. To our knowledge, no research exists that tackles this question. When investigating study guides and the relationship between this instrument and students' learning patterns and motivation, it seems imperative to take students' perceptions into account. Not only is there little point in investing faculty's scarce time and energy into an instrument when little added value is perceived, research has also convincingly shown, that students perceptions play a crucial role in determining whether an educational intervention have

any effect on students' learning. According to Entwistle, it is not the learning environment in itself that influences learning but the way students perceive it (Entwistle, 1991). Students always interpret instructional measures or innovations and the result of this interpretation will determine whether students will let them 'be influenced' by these measures (Elen & Lowyck, 2000). Therefore student perceptions form the critical link between learning and motivation and instructional measures or innovations (Ramsden, 2000), in the case of the present study, the use of study guides.

3 Problem statement

We discussed the study guide as an instrument that helps students' self-regulated learning in a learning environment in which students are given increasingly more freedom and responsibility. The importance of students' perception of the learning environment was also discussed. It is not the educational reality that influences students' learning but the reality as perceived by the students, their perception. If we transpose this to the use of study guides, as a part of the learning environment, we can state that students' perception of study guides is of utmost importance. Therefore it is relevant to empirically explore students' use and perception of study guides. In this research not only students' perception of study guides concerning their own use was analysed, but also students' perception of the use of study guides by their faculty was explored.

Another important aspect is individual differences in learning. As differences in learning approaches between students are present in learning environments, it might also be related to a differential perception of these study guides. It could be hypothesized that study guides are perceived differently by learners who learn more external instead of self-regulated. Literature showed that there is a strong correlation between students' learning approach and their perception of the learning environment. (Diseth, 2007; Dochy et al., 2005; Marton & Säljo, 1997; Struyven et al., 2006). The way students perceive features in the learning environment is relevant for the learning approach they will adopt. Up until now no research has been done on the relationship between students' learning approach and their perception of study

guides as a part of the learning environment. To fill this hiatus the relationship between students' perception of study guides and learning patterns was researched.

To summarize, the research questions of this study are the following:

RQ 1: How do students use and perceive study guides?

RQ 2: How do students perceive faculty's use of study guides?

RQ 3: What is the relationship between students' perceptions of study guides, and their learning patterns (a) and motivation (b)?

These research questions can be situated in a model of students' learning (see figure 1). Considering the focus of this study we limited ourselves to the operationalisation of three factors, considering their relevance in literature as described in the theoretical framework: students' perception of study guides, motivation, processing strategies and regulation strategies.

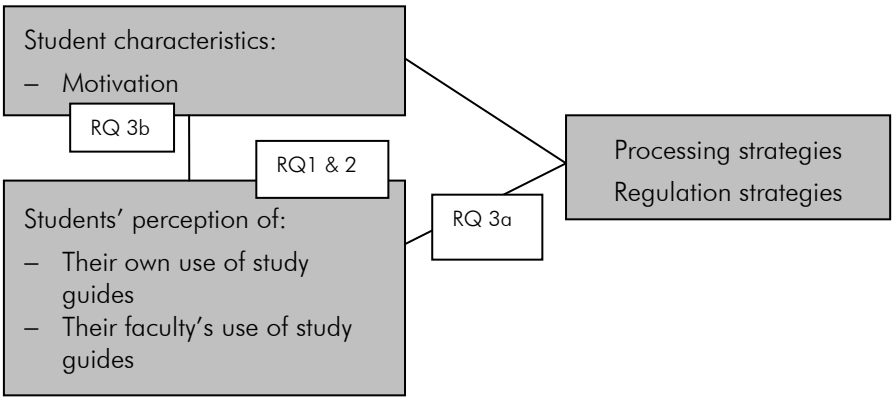


Figure 2: Research model of students' learning (based on 3P-model, Biggs, 1993; 2003).

4 Method

4.1 Participants

In 2009 in the period October-December, 69 students from the first bachelor Applied Economic Sciences at the University of Antwerp filled out a questionnaire. We chose freshmen students because these students are likely in need of more support in becoming self-regulated learners. This kind of support can be provided by an instrument like the study guide.

4.2 Instruments

4.2.1 Learning patterns and motivation

Students' learning patterns were measured with the Learning and Motivation questionnaire, or LEMO (Donche & Van Petegem, 2009), an adapted and shortened version of Vermunt's Inventory of Learning Styles (ILS). The questionnaire contains 67 items. All items were scored on a five-point Likert scale. The questionnaire contains two processing strategies: deep processing and stepwise processing. The questionnaire distinguishes three regulation strategies: internal regulation, external regulation and lack of regulation. Students' motivation is also measured using the Self-determination Theory (SDT) framework by an adapted and translated version of the Self-Regulation questionnaire (SRQ). The subscales are consistent with those in self-determination theory (Deci & Ryan, 2002): 'autonomous motivation', 'controlled motivation', 'amotivation', 'extrinsic motivation', 'introjected motivation', 'identificated motivation', and 'intrinsic motivation'.

Table 2. Number of items and internal consistency per scale of the LEMO-questionnaire.

Scale	*N*	*a*
Processing strategies		
– Deep processing	8	0.78
– Step-wise processing	8	0.78
Regulation strategies		
– Internal regulation	4	0.65
– External regulation	8	0.62
– Lack of regulation	4	0.65

Motivation		
– Autonomous motivation	8	0.82
– Controlled motivation	8	0.76
– Amotivation	3	0.81
– Extrinsic motivation	4	0.72
– Introjected motivation	4	0.74
– Identificated motivation	4	0.63
– Intrinsic motivation	4	0.87

4.2.2 Study guides' perception

To measure students' perception of study guides we developed a questionnaire. This questionnaire contains 73 items. We opted for the use of a seven-point scale as this study entails perception research. In the questionnaire only the extreme answer possibilities of the scales were given, that is 'totally do not agree' and 'totally agree'. A step-wise validity check was done with the Cronbach alpha values.

The questionnaire is subdivided into three parts. The first part deals with *students' use of study guides*. This part consists of four scales: intensity, frequency, internal regulation and external regulation. With the Cronbach-*a* value being low, we should be cautious with the interpretations and implications of the 'external regulation' scale. The scales 'internal regulation' and 'external regulation' map students' perception of the study guide's impact on the regulation of their learning process. The scale 'intensity' measures which sections of the study guide students generally use. This scale measures the intensity or thoroughness with which students made use of the study guide. The scale 'frequency' measures how often and at which moments during the academic year students actually consult study guides.

The second part of the questionnaire measures *faculty's use of study guides* as perceived by their students. The scales correspond with the scales of the previous part about students' use of study guides, but are adapted to the perspective of faculty (according to their students). The scales 'internal regulation' and 'external regulation' verify whether faculty (according to students) use study guides as instruments to stimulate internal and/or external regulation with their students. The scale 'intensity' measures the extent to which faculty refer to their study

guides according to students. With the scale 'frequency' is measured how often faculty refer to their study guides according to students.

The third part of the questionnaire measures *students' general perception of study guides*, which was made operational by merging five scales into one main scale in order to form a clear image of general perception. The five scales are: 'appreciation', 'clarity', 'helpfulness', 'quality', and 'general assessment'. The internal consistency of this scale is very good. Moreover three control questions are included. The correlation between the control questions and the corresponding questions is significantly positive (r=.453, p<.001; r=.465, p<.001; r=.601, p<.001).

Table 3. Number of items and internal consistency per scale of the study guide questionnaire.

Scale	*N*	*a*
Students' perception and use		
– Internal regulation	7	0.74
– External regulation	3	0.53
– Intensity	8	0.79
– Frenquency	5	0.73
Students' perception of faculty's use		
– Internal regulation	6	0.79
– External regulation	3	0.52
– Intensity	5	0.64
– Frequency	4	0.77
Students' general perception		0.85
– Appreciation	6	0.76
– Clarity	6	0.84
– Helpfulness	7	0.82
– Quality	6	0.68
– General assessment	7	0.87

4.2.3 Study guides in this study

The study guide variant used in this study concerns an electronic study guide. The study guides can be consulted on an electronic learning environment. For reasons of conformity, study guides are often implemented by faculty in a standard template provided by the

university. This template can contain sections such as expected starting competences, learning objectives, content, instructional methods, evaluation, study material and support. In every section of the template, space is provided where faculty can add extra information.

4.3 Analysis

The internal consistency of both questionnaires was measured in order to verify whether the (combined) indicators form a consistent dimension. After that, the mean scale scores and standard deviations were calculated. In this way, research questions 1) and 2) were answered. To answer research question 3) a correlation and a regression analysis were conducted.

5 Results

As the alpha values range from acceptable to very good we will report on scale level.

5.1 Students' use and perception of study guides

5.1.1 Internal regulation

Students' use and perception of study guides is measured using a seven-point scale. The mean score on the scale 'internal regulation' is rather low. This implies that most students do not consider study guides as an instrument that fosters their internal regulation. If we consider the items of this scale separately, we see that students score higher on two items. 59.4% (students who answer with a scale of ≥4) indicates that they use study guides to know/realize what knowledge they will have acquired after taking a course module (M=4.12, SD=1.92). 47.8% says they use study guides to determine their study approach for a course module (M=3.46, SD=1.81). Furthermore, only 27.5% of the students agree that study guides help them to prepare their course modules independently (M=2.71, SD=1.63) and to plan their study themselves (M=2.75, SD=1.37).

5.1.2 External regulation

The scale 'external regulation' scores high. In general students consider study guides as instruments that externally regulate their learning process. 78.3% indicates that they use study guides to know what faculty expect from them on the exam (*M*=4.67, *SD*=1.69) and 77.9% to know what faculty expect them to know (*M*=4.63, *SD*=1.60). 49.3% uses the study guide to know what faculty expect concerning the preparation of the course module.

5.1.3 Intensity

The scale 'intensity' measured how thoroughly students consult the different parts of study guides. The average value of this scale is high. This indicates that students generally read the different parts of study guides thoroughly. 95.6% say they read the part about the evaluation thoroughly to very thoroughly (*M*=5.99, *SD*=1.23). Moreover the parts about the start competences (*M*=5.14, *SD*=1.70), the end competences (4.87, *SD*=1.84) and the content (*M*=5.14, *SD*=1.31) are read thoroughly. As well as the parts about the study material (*M*=4.93, *SD*=1.89), the objectives (*M*=4.81, *SD*=1.45) and the instructional methods (*M*=4.61, *SD*=1.55).

5.1.4 Frequency

81.2% of the students reads study guides in the exam period (*M*=4.90, *SD*=1.80). 78.3% takes a look at the study guide when choosing course modules, but opinions tend to differ widely (*M*=5.10, *SD*=2.05). 65.2% reads the study guide at the beginning of a course module. But also about this period opinions seem to differ (*M*=4.35, *SD*=2.04). Only 29% of the students indicates to read the study guide during the semester (*M*=2.94, *SD*=1.69).

Table 4. Means and standard deviations of items from the study guide questionnaire about students' use of study guides (on a seven-points scale).

Scale	Sample item	*M*	*SD*
Internal regulation	*In general I use study guides because they help me to prepare my exam autonomously.*	3.19	1.05
External regulation	*In general I use study guides to find out what faculty expect me to know.*	4.30	1.21
Intensity	*In general I read the section about instructional methods.*	5.09	1.02
Frequency	*In general I use study guides regularly.*	4.32	1.37

5.1.5 General perception

In general students tend to have a positive perception of study guides (*M*=4.52). Their opinion on this does not differ widely (*SD*=0.86). Only 7.2% perceives study guides negatively. 63.7% of the students is positive with regard to study guides and 28.9% is very positive towards study guides.

5.1.6 Appreciation

Students appear to strongly appreciate study guides (*M*=5.07, *SD*=0.98). 95.7% of the students agree that study should continue to be used guides (*M*=6.17, *SD*=1.22). 92.8% thinks that study guides are useful (*M*=5.61, *SD*=1.24). Moreover 66.7% of the students says that study guides have an added value when preparing exams (*M*=4.23, *SD*=1.75). To a lesser extent, 43.5% indicates that study guides have an added value when preparing course modules (*M*=3.37, *SD*=1.88).

5.1.7 Clarity

Students indicate that study guides provide them clarity. 66.7% of the students thinks that study guides clarify what is expected in the exams (*M*=4.17, *SD*=1.84). Study guides also clarify what students should master in knowledge and skills (*M*=4.62, *SD*=1.47; *M*=4.50, *SD*=1.59). 63.8% says that study guides clarify how a course module will progress.

5.1.8 Helpfulness

Students consider study guides a useful instrument in their learning process (*M*=3.43, *SD*=1.13). 58% of the students indicate that study guides help them to prepare their exams (*M*=3.90, *SD*=1.59). Only 34.8% thinks that study guides help them to prepare lectures. 55.9% indicates that study guides help them to study more efficiently (*M*=3.72, *SD*=1.77). 50% says that study guides help them planning their study (*M*=3.32, *SD*=1.56). According to only 36.8% of the students study guides help them processing the learning material. 36.2% indicates that study guides help them being less insecure. Study guides thus appear to be especially helpful with practical and concrete aspects.

5.1.9 Quality

According to students it is important that certain features are fulfilled in order to speak of quality study guides (*M*=5.11, *SD*=0.95). 97.1% of the students think that it is very important that study guides are complete

M=6.17, *SD*=1.20). 94.2% indicates that study guides should be in accordance with what faculty says during lectures (*M*=6.20, *SD*=1.32). 79.7% is of the opinion that study guides should be comprehensive (*M*=4.94, *SD*=1.77). 59.4% indicates it is important that study guides are often referred to during lectures.

5.1.10 General assessment

In general, students assess the current study guides as positive (*M*=4.70, *SD*=1.14). They indicate clearly that study guides should remain in use (95.7%). 85.5% thinks study guides are clear and useful (*M*=5.07, *SD*=1.33; *M*=5.23, *SD*=1.48). Furthermore, 79.7% considers their study guides as complete (*M*=4.51, *SD*=1.40); which was also an important criteria in the quality assessment (see 1.9). Students also perceive their study guides as helpful and comprehensive (*M*=4.87, *SD*=1.49; *M*=4.58, *SD*=1.54). 62.3% indicates that study guides motivate them (*M*=3.91, *SD*=1.52).

Table 5. Means and standard deviations of items from the study guide questionnaire about students' perception of study guides (on a seven-points scale).

Scale	Sample item	*M*	*SD*
Appreciation	*In general I think that faculty should continue working with study guides.*	5.07	0.98
Clarity	*In general I think that study guides clarify what faculty expect on exams.*	4.30	1.17
Helpfulness	*In general I think that study guides help me preparing my course subjects.*	3.43	1.13
Quality	*I think it is important that study guides are complete.*	5.11	0.95
General assessment	*In general I consider study guides as motivating.*	4.70	1.14

5.2 Students' perception of faculty's use of study guides

5.2.1 Internal regulation

This scale measures how students perceive faculty's use of study guides. In general, students think that faculty use study guides to stimulate the internal regulation of their learning process (*M*=4.10, *SD*=1.16). 81.2% thinks that faculty use study guides to clarify what they expect their students to know after taking a course subject (*M*=4.91, *SD*=1.59). 64.7%

indicates that faculty use study guides to help determine their students how to tackle a course subject (*M*=4.25, *SD*=1.70).

5.2.2 External regulation

This scale measures whether students think that faculty use study guides to stimulate their external regulation. This appeared to be the case (*M*=4.93, *SD*=1.11). 72.5% indicates that faculty use study guides to clarify what is expected on the exam (*M*=5.10, *SD*=1.56) and what should be known for the exam (*M*=4.49, *SD*=1.63). 76.8% are of the opinion that faculty use study guides to clarify what they expect concerning the preparation of lectures (*M*=4.49, *SD*=1.63).

5.2.3 Intensity

87% of the students indicate that study guides contain sufficient information (*M*=5.13, *SD*=1.32). Moreover, 91.3% thinks that study guides in general contain correct information (*M*=5.36, *SD*=1.22). 63.8% says that study guides are filled out relatively well (*M*=4.16, *SD*=1.82). A remarkable result is that only 23.2% indicates that faculty go over their study guide in lectures.

5.2.4 Frequency

Students indicate that study guides are only referred to in a limited degree (*M*=3.05, *SD*=1.26). If faculty refer to their study guide, they do this during the exam period (*M*=3.53, *SD*=1.34) or at the start of a course subject (*M*=3.71, *SD*=1.92). During course subjects, faculty only appear to refer to their study guides limitedly (*M*=2.01, *SD*=1.38). According to only 16.2% of the students, faculty refer regularly to their study guide.

Table 6. Means and standard deviations of items from the study guide questionnaire about faculty's use of study guides as perceived by their students (on a seven-points scale).

Scale	Sample item	*M*	*SD*
Internal regulation	*In my opinion most faculty use study guides to help me plan my study autonomously.*	4.10	1.16
External regulation	*In my opinion most faculty use study guides to clarify what is expected on the exam.*	4.93	1.11
Intensity	*In general study guides contain correct information.*	4.91	1.03
Frequency	*Most faculty regularly refer to their study guides.*	3.05	1.26

5.3 Relation between students' perception of study guides and learning patterns

5.3.1 Correlational analysis

To explore the relation between students' perception of study guides and their learning patterns, a correlational analysis was carried out. The scales of the study guide questionnaire and the perception of study guides show a strong correlation. Internal as well as external regulation with faculty and student correlate strongly to very strongly with perception of study guides. This indicates that the more students or faculty consider study guides as an instrument to regulate their learning process, the more positive their perception of study guides is. Also the intensity and frequency in use correlate highly. The more thoroughly and frequently students and/or faculty use study guides, the more positive their perception of study guides.

Table 7. Correlations between scales study guide questionnaire and general perception of study guides.

Schalen	r_s	P
Interne regulatie docent	0.27	0.02
Interne regulatie student	0.51	0.00
Externe regulatie docent	0.24	0.05
Externe regulatie student	0.57	0.00
Intensiteit docent	0.57	0.00
Intensiteit student	0.50	0.00
Frequentie docent	0.55	0.00
Frequentie student	0.56	0.00

When looking at the relation between the learning patterns and the perception of study guides, there appears to be a strong correlation between the scale 'analyzing' and perception of study guides. Students that learn analytically or methodically will generally have a rather positive perception of study guides. Students who are motivated by external pressures or who lack motivation will have a rather negative perception of study guides. This result is surprisingly unexpected since the study guide is an instrument that can help students to have their learning process regulated by faculty (and their expectancies). This also holds true for deep processing. The relationship between identified

motivation and perception of study guides is also relatively strong. This means that students who learn because they see their study as personally relevant, have a rather positive perception of study guides.

Table 8. Correlations between learning patterns and and general perception of study guides.

Schalen	r_s	*p*
Diepteverwerking	0.22	0.07
Diepteverwerking: relateren en structureren	0.17	0.16
Diepteverwerking: kritisch verwerken	0.21	0.09
Interne regulatie	0.17	0.16
Externe regulatie	0.18	0.14
Stuurloos	0.03	0.79
Stapsgewijze verwerking	0.25	0.04
Stapsgewijze verwerking: analyseren	0.42	0.00
Stapsgewijze verwerking: memoriseren	0.05	0.67
Gecontroleerde motivatie	0.01	0.96
Extrinsieke motivatie	-0.31	0.01
Geïntrojecteerde motivatie	0.13	0.27
Autonome motivatie	0.27	0.03
Geïdentificeerde motivatie	0.30	0.04
Intrinsieke motivatie	0.19	0.12
Amotivatie	-0.30	0.01

5.3.2 Regression analysis

Since we have found a relevant relationship between the processing strategies, the regulation strategies, and motivation, a regression analysis was conducted to examine this correlation into more detail. By conducting a regression analysis with the scales of the study guide questionnaire as independent variables, we verified the relation between students' perception of study guides on the one hand, and students' learning patterns and regulation features on study guide level on the other hand. At first all scales were added as independent variables to subsequently reduce variables and come to a good model. For the study guide questionnaire, the four variables that measure regulation were added as independent variables: internal and external regulation used by students as well as faculty. The perception of the study guide was

added as a dependent variable. Finally, two variables were added to the definitive model, the internal ($p<.01$) and external regulation ($p<.001$) with the use of the students. The model with these variables included is significant ($p<.001$) and accounts for 39.8% of the variance of study guide perception. The effect of external regulation is the strongest ($\beta=.43$), but the effect of internal regulation is also strong ($\beta=.30$). Both variables have a unique variance of 76%. No multicollinearity problems were found.

A similar regression analysis was conducted with the variables from the questionnaire about learning patterns. The scales as well as the subscales of processing, regulation, and motivation were added as independent variables, and perception of the study guide was added as a dependent variable. In the definitive model only one variable remained: the subscale 'analyzing' with stepwise processing. The higher students score on the subscale analyzing, the more positive their perception of study guides. This model explains 17.7% of the variance in perception of study guides and the model is significant ($p<.001$).

Subsequently we carried out a regression analysis with the variables that remained from the two previous models as independent variables, namely the internal and external regulation with the use of the student and the subscale analyzing. This model explains 45.8% of the variance in perception of the study guide and is significant ($p<.001$). The external regulation of the student has the strongest effect in this model ($\beta=.36$). Internal regulation and analyzing have approximately the same strength of effect ($\beta=.29$; $\beta=.26$). No multicollinearity problems were found in this model.

Finally, the influence of frequency and intensity with which students and faculty use study guides on students' perception of study guides was investigated. The regression analysis shows that these four independent variables explain 64.2% of the variance in the perception of the study guide. The more frequent and positive students' perception of study guides, the more positive students' perception of study guides is. The model is significant ($p<.001$), so it can be generalized to the population. The intensity with which faculty use study guides has the strongest effect on the perception of students ($\beta=.42$). The frequency with which students and faculty use study guides also have a relatively strong effect ($\beta=.27$; $\beta=.30$). The effect of the intensity with which

students use study guides is less strong (β=.18). The model shows no multicollinearity problem.

If we verify the percentage of this model that is explained by students and how much by faculty, we conclude that most variance is explained by the faculty. Faculty thus shows the strongest effect: the frequency and intensity with which faculty use study guides explains 51.2% of the variance. How often and how thorough faculty use study guides, has a large influence on students' perception of study guides. Students explain 37.3% of the variance in this model. The more frequent and the more thorough students use study guides, the more positive their perception.

6 Conclusion and discussion

In this research students' use and their perception of study guides was investigated. Most students do not view study guides as an instrument that stimulates the internal regulation of their learning process to a strong extent. However, students do strongly consider study guides as an instrument that stimulates their external regulation. In general, students use the different parts of study guides thoroughly. Furthermore, they seem to use study guides especially during the exams and when choosing their course modules. A remarkable result of this research is that students generally have a positive to very positive perception of study guides. Students strongly appreciate study guides and agree that they should remain in use. They think that study guides offer them clarity and help them in their learning process. A few students have indicated that study guides help them to be less insecure, but this concerns a limited group. Students also think that study guides induce motivation.

According to students, it is important that certain requirements are met in order for study guides to be qualitative. They should be complete and in accordance with what faculty say during lectures. In general, students indicate that study guides should be used often during course modules. Overall, most students perceive them to be clear, useful and more complete. Furthermore, they consider study guides helpful and elaborate.

The second research question examined students' perception of the use of study guides by their faculty. In general, students agree to a certain extent that faculty use study guides to stimulate the internal regulation of their learning process. To a stronger extent they indicate that faculty use study guides to stimulate their external regulation. It is remarkable that students indicate that faculty hardly refer to study guides during lectures.

The third research question concerns the relationship between students' perception of the study guide and their learning patterns and motivation. Therefore, a correlation and a regression analysis were conducted. A correlation was found between 'analysing' (processing strategy) and perception of the study guide. Students who learn analytically or methodically will generally have a more positive perception of study guides, whereas students who are extrinsically motivated or amotivated will have a rather negative perception of study guides. Thus, if students are not motivated, they will not perceive study guides as motivating. The correlation between 'identified motivation' and perception of the study guide was also relatively strong. This indicates that students who learn because they consider their study personally valuable or relevant have a rather positive perception of study guides. Contrary to all expectations, external regulation and deep processing do not show a positive relation with perception of study guides. In conclusion, study guides are perceived equally positive by students with differing learning patterns.

The regression analysis of both questionnaires showed that analyzing (stepwise processing), and internal and external regulation (on study guide level) form a model that explains almost half of the variance within perception of the study guide. Students that learn analytically, and thus work very methodically, have a positive perception of study guides. That these students have a positive perception of study guides seems obvious since study guides help them analyzing. The frequency and intensity with which students and faculty use study guides explains 64.2% of the variance within study guide perception. This means that the more frequent and intensive students and faculty use study guides, the more positive their perception is. Especially the frequency and intensity with which faculty use study guides have the strongest influence on students' perception.

7 Limitations and further research

This research has some limitations. Students' perception and their use of study guides was only measured by means of self-report measures. Besides questionnaires, other methods should be used, such as qualitative research. As this was an exploratory study, the number of participants was relatively low. The context of this research was also rather specific. A specific group of students of a specific university was selected. Furthermore, only cross-sectional data were used.

This exploratory study has a number of implications for future research. Further comparative mixed-method research is thus strongly recommended. Additionally, different contexts in higher education should be studied with a larger group of participants. Finally, quasi-experimental research with a control group is recommended.

8 Implications for practice

Research shows that study guides have the potential to be a valued and useful instrument. However, based on results, some guidelines and pitfalls can be discerned for the use of study guides in educational practice.

This research has shown that students' perception of study guides is very positive in general. But there also appear to be some differences in perception. Some students have a less positive perception of study guides. These differing perceptions correlate, amongst others, with students' learning approach and their learning motivation. In particular, students who experience pressure have a rather negative perception of study guides, while students who tend to learn by stepwise processing have a more positive perception of study guides. Further research is needed to establish whether a positive perception of study guides is influenced by a need for external regulation, which is common for students who learn by stepwise processing. If this appears to be the case, it would implicate that the current format of study guides especially appeals to a certain group of learners with similar learning patterns.

Therefore, we have to be careful that the study guide does not overshoot its goals by remaining too externally regulating.

Furthermore, this research shows that faculty should prevent study guides from becoming an idle document. Faculty can increase the use of study guides by regularly referring to its study guides. This research demonstrated that the more frequently faculty refer to their study guides in lectures, the more positive students' perceptions of study guides are. As was discussed earlier, this is a relevant finding considering that students' perception of the learning environment has an important influence on their learning approach (Biggs, 1993; Entwistle, 1991; Ramsden, 2000). It is not the educational reality but the reality as perceived by the students, i.e. their perception, which influences students' learning. So if faculty want to change their learning environment, they have to take into account students' perception. Thus, by referring more regularly to the study guide, faculty can positively influence students' learning. This also makes the study guide more of a learning instrument.

The study guide primarily appeared to be an information instrument and, to a much smaller degree, a working and support instrument. Possibly, the rather negative perception of some students might change positive by addressing more or different issues in order to reach more students. Students might need more than mere information for study guides to have an effect on their learning process. As was already suggested, faculty can appeal to the function of study guides as learner instruments by regularly referring to them. The function of study guides as a support instrument can be further exploited by, for example, systematically including study planners. Another example for broadening the use of study guides is that they can also be used as a communication instrument between faculty or within departments. It goes without saying that a stronger alignment between faculty and their practices is for the better.

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COLLABORATIVE INNOVATION OF THE SCIENCE CLASSROOM THROUGH PARTICIPATORY ACTION RESEARCH –

Theory and Practice in a Project of Implementing Cooperative Learning Methods in Chemistry Education

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ABSTRACT

To solve the problem of the existence of different communities within domain-specific educational research (namely empirical researchers, curriculum developers, and practitioners) and a lack of sustained interaction between these communities, the model of Participatory Action Research (PAR) for domain-specific educational research is presented. An example of implementing cooperative learning into the chemistry classroom is summed up. Finally, the potential of PAR for innovating the practice of science teaching is reflected on.

KEY WORDS: Collaborative Innovation, Participatory Action Research, Cooperative Learning Methods, Chemistry Education, Science Classroom

1 The Two-(or three)-Communities-Problem in Domain-Specific Educational Research and Practice

Domain specific education always has to balance between being a social science in its objectives and methods on the one hand and dealing with

its reference discipline on the other. This reference discipline might be a social science or a language, the arts, or the natural sciences. Thus, the academic field of chemistry education has connections to both fields: educational sciences and chemistry as one of the natural sciences. The objectives of and the methods applied in both fields differ very much. They range from empirical research on learning processes using the standard methods of the social sciences to research into the means of creating new experimental tasks for students to integrate new discoveries from chemistry into education. Thus, in Germany, as in many other countries, a controversial debate exists about whether chemistry education as an academic discipline should be more closely related to chemistry or to education, and about what should count as research in chemistry education (see. e.g. Ralle & Eilks, 2002).

Within the discussion on chemistry education research, Eilks & Ralle (2002) suggested defining two central fields of domain-specific educational research: *empirical research on learning processes* and *curriculum development*, as *pure* and *applied research* respectively. Although both fields are (or should be) related to one another, and in some cases are even combined, they can be differentiated by the activities of the participants. *Pure research,* with the primary objective of obtaining empirically based insights into the processes of learning chemistry, applies mainly classical empirical methods from the educational sciences. The research paradigm behind it is often more or less positivistic. Applied research, however, follows the primary objective of inspiring changes in teaching practice using a variety of activities, including the development of new curricula, teaching strategies and materials. The research paradigm behind it is often unclear, but frequently oriented towards the reference discipline, which in chemistry means the research theory of the natural science.

According to De Jong (2000), one of the main system failures in domain specific educational research in the field of chemistry education is the missing interaction of the two fields discussed above. We have a problem of two more or less independent communities. Empirical researchers frequently don't care about the needs of practitioners and often don't successfully communicate their findings to them. On the other hand, curriculum developers sometimes don't recognize research evidence about teaching and learning enough and also neglect questions

of sustainable implementation (e.g. de Jong 2000; Costa, Marquez, & Kempa, 2000; Taber 2001; van Driel, Beijaard & Verloop, 2001; Eilks & Ralle, 2002). In many countries each community has their own journals, societies and conferences. But the more these communities fail to interact, the more they will stay separate from each other in their behaviours, intentions and practices.

Another important party is the chemistry teachers, who are seldom educated in the methods of doing either pure or applied chemistry education research. Their interest is neither the search for new empirical evidence about learning and instruction, nor the development of curricula of general interest. Their primary interest is coping with everyday educational practice. The teachers form a third community, which is often described in literature as having little contact with any kind of educational research. Hubermann (1993) described his '*two communities problem*' between practitioners and researchers as a difference in norms, rewards and working arrangements. This two-communities-problem is not specifically related to chemistry education; it exists in many other educational domains as well (Wilson & Berne, 1999).

Huberman (1993) concluded that the only way to bridge the existing gap between research and classroom teaching or curriculum development is through *sustained interactivity.* He states that it is necessary to have '*multiple exchanges between researchers and potential "users" of that research at different phases of the study*' (Huberman, 1993, p.4). He suggests looking for convergences between the scope of the research and the priorities and interests of the target audience, as well as recruiting key actors in the target audience to accompany the research and help to carry it out. This help could take the form of e.g. participating in review and analysis of intermediate findings or identifying data sets of greatest potential use to the target audience. Such interaction recognises the consideration that both empirically validated research results and experientially-based teacher knowledge are two ends of a spectrum of knowledge about teaching and learning, both of which are equally important and have their own strengths (McIntyre, 2005).

Finally, Huberman's understanding of *sustained interactivity* also includes common planning of how to make the results valuable to the

target audience and how to disseminate the findings into practice. This is or should also be the objective of any pure researcher or curriculum developer. Acknowledging that the teacher is the key to any sustainable innovation in practice (Anderson & Helms, 2001), we have to keep in mind that any sustainable reform and implementation can only be successful if teachers` beliefs, their prior knowledge and attitudes are seriously taken into account in the reform (Haney, Czerniak & Lumpe, 1996; Nespor, 1987) and then developed step-by-step through experience-based learning and reflection (Huberman, 1993).

The considerations discussed above influenced our search for new strategies to develop an interactive model of domain-specific educational research with the aims to develop the curricula, innovate authentic practices and build empirical evidence about processes of learning and instruction. The design of Participatory Action Research (PAR) in chemistry education (e.g. Eilks & Ralle, 2002; Eilks 2003; Eilks, 2007) is thought to integrate both pure and applied research as well as the domain of practice into domain-specific educational research.

2 Towards a Model of Collaborative Innovation Using Participatory Action Research

There is a whole range of models integrating research and practice in educational fields, respectively making the collaboration of researchers and practitioners the core of the research. Each model uses different methodologies and contains differing focal points under keywords such as *Content Focussed Coaching* (Staub, West & Bickel, 2003), *Teachers' Learning Communities* (Putnam & Borko, 2000), *Knowledge-creating Schools* (McIntyre, 2005), and i.e. various forms of *Action Research* (e.g. Bencze & Hodson, 1999; Feldman, 1996; Parke & Coble, 1997). Differences are mainly observable in the question of power and control of the research process, which can be either more on the researchers' side or the practitioners' side (Eilks & Ralle, 2002). Some models even make freedom and control a central issue of the model itself (Eilks & Markic, submitted; Mamlok-Naaman & Eilks, submitted).

From our point of view, for applied academic educational research within domain-specific education, the main objectives are the development, documentation and implementation of new or improved curricula and teaching materials. The goal is to develop strategies and materials that can potentially improve practice in as many learning groups as possible. Thus, we do not consider Action Research approaches that are too practitioner-centred to be the most appropriate for applied domain-specific educational research. We consider as more appropriate those approaches that focus on obtaining more generalised results than approaches that strive primarily to solve problems within individual groups. *Participatory Action Research (PAR)* as it was described in the filed of economics by Whyte, Greenwood & Lazes (1989) seems to us an appropriate research model to be adapted to chemistry education. The objective of this method is to derive results that are widely applicable and based on empirical observations of authentic practices. Even so, the method also intends to improve the actions of the practitioners involved. For education, that means that curricula are developed for real-life practice situations in individual learning groups and that the teachers who are involved are trained as a part of the research process. Therefore, we defined as objectives of the research process (see Figure 1):

- the development of teaching strategies and materials that can improve teaching and learning practice, and the evaluation and dissemination of teaching and learning strategies,
- the attainment of empirical evidence about the applied learning and teaching practices,
- the reduction of deficits in concrete teaching practice involved in the process,
- the in-service teacher training of the involved practitioners, as pertains to their awareness of how well they work and improving skills in curriculum development and evaluation, and the documentation of the settings and experiences as examples of good practice.

Action Research is generally described as a co-operative process between practitioners and external individuals, in this case teachers in classroom practice and science educators from the university. As a matter of principle, the persons involved have equal status and they all contribute to all of the decisions made during the research and

development process. The objective is to come to a consensus within the group and to agree upon a common strategy. But in the end, any decisions concerning changes in actual practice are left up to the respective teacher. Although both groups are of equal status, it is helpful to think of them as having different roles (cf. Altrichter & Gstettner 1993). The external researchers focus on organising and co-ordinating the research process, developing and justifying the changes in practice and evaluating their effects. The teachers concentrate their efforts on translating the new methodological elements into their practice and testing the changed approaches (Figure 2).

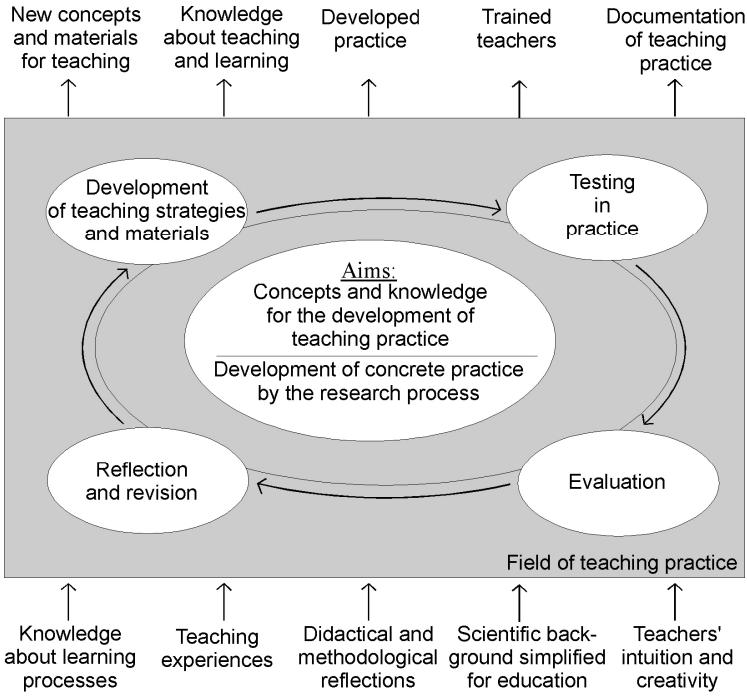


Figure 1. Participatory Action Research within domain-specific education (Eilks & Ralle, 2002)

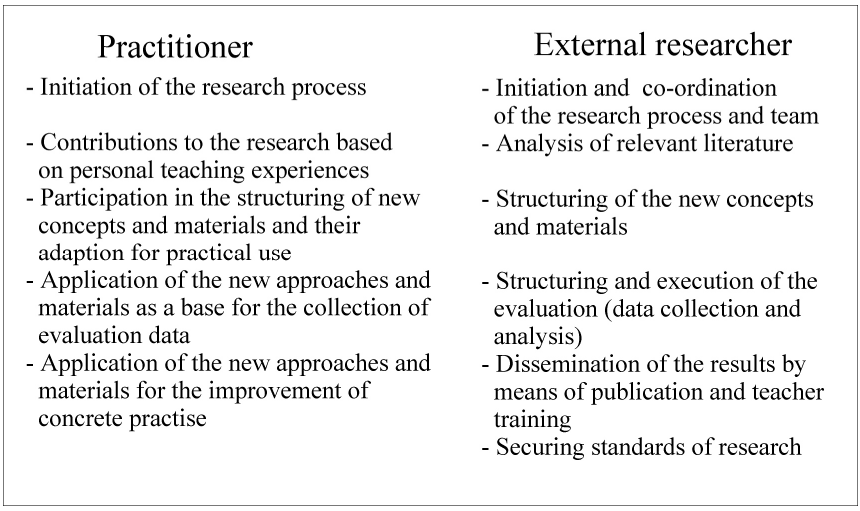


Figure 2. Roles of practitioners and researchers

In the working process, it is important to remain aware of these different roles. Altrichter & Gstettner (1993) warn that there is a risk of the external researcher strongly dominating the team. This risk exists because of the widely held belief that theoretical knowledge is of "more value" than practical experiences, and it can also be due to the implicitly hierarchical relationships between universities and schools:

> "*The abstract concepts of 'theory' and 'practice' were often too easily personalised in the sense that professional researchers stood for 'theory' and practitioners for 'practice'. Thus, a hierarchy was established which made learning in the other direction more difficult: e.g. the development of the researchers' theory and practice through theoretical and practical critique by practitioners.*" (Altrichter & Gstettner 1993, p. 344)

But, the awareness of the different roles also provides an opportunity to learn. The tension between the different individuals involved makes it necessary to discuss their different points of view. This can lead to more awareness of and reflection on the relative values of theory and practice and the different viewpoints of teachers and external researchers. In this sense, Action Research is believed to generate more understanding between the two groups, because both perspectives can be of value for the process of innovation (McIntyre, 2005) and have potential for

breaking down the barriers between schools and universities (Noffke 1994).

In our model, the research process is initiated when deficits either in teaching practices or in empirical research are reported. Research is intended to find methods for eliminating or reducing problems in practice. The research starts by a thorough analysis of the relevant literature. Group discussions between researchers and teachers are used to determine whether or not the problem is of general interest beyond one individual classroom. The group discussions are also used to reflect on whether evidence and ideas documented in the literature can offer help to a specific educational setting the teachers work in. Several questions are central to this analysis: 1. Have similar and/or related problems been documented? 2. Are results from empirical research available? 3. Have attempts been made to reduce these deficits? This analysis must be done with the practitioners to ensure that the developed strategies and collected data are relevant with respect to the problems that exist in practice. In order to structure, improve, test and evaluate practice, it is essential to gather background information from scientists and scientific literature, and to learn about and from the experiences, intuition and creativity of researchers and practitioners alike (Figure 1).

Every kind of Action Research is described as being cyclical. This is one of the main differences between action research and more conventional research designs (Wadsworth 1998). At the start, new teaching approaches are designed that are then used and tested with the objective of improving practice in the testing groups. These initial designs are used and tested as early as possible to see whether they have the potential to solve problems in teaching practice. The external researchers and the teachers plan the implementation of the curricula together. The process of planning as a group is important because it ensures that the designs are compatible with the needs of everyday practices. The inclusion of practical teacher experiences is one of the main differences between the PAR method and the way that curricula are normally developed, where the teacher only becomes a consumer of readily developed materials.

In terms of critical theory (Moser, 1975; Masters, 1995), a central objective of any action research is to improve practice step by step with each cycle of development. In order to do so, each of the cycles has to be analysed and evaluated. The evaluation should take the perspectives of all of the participants (teachers, students, and researchers) into consideration. On the other hand, the curricula are developed within a practice setting and using close cycles of development and testing. For this reason, evaluation tools and strategies should be chosen that are appropriate for the setting. They can be adapted during the research process as needed, and they should be further improved during each cycle of development. Several methods are suitable, e.g. standardised questionnaires, documentation of verbal feedback, group discussions among the practitioners, or sample interviews with the students.

It has been suggested, e.g. by Bodner, MacIsaac, & Whyte (1999), that classical strategies that apply a quantitative understanding of evaluation are not appropriate for this kind of curriculum development. That is because there are far too many influencing factors, and the researchers and practitioners are personally involved. A qualitative and interpretative paradigm is more suitable for this type of research. The validity of the interpretations can be tested and/or confirmed in discussions between researchers and practitioners, and within the practitioners' group. The criteria defined by Altheide & Johnson (1994) can be used as a guideline: plausibility, credibility, relevance and importance. As opposed to classical procedures, the practical experience of the teachers, and their assessment of their teaching success, plays an important role in evaluating the research.

If the evaluation indicates that the curriculum changes are successful at reducing teaching and learning deficits, the development and research process can be continued in a new phase that will potentially lead to even more improvement. The newly developed research phase should try to determine the reasons behind the deficits, and the impact of the changes that were made during the previous round of research. The intention is to obtain general, yet relevant background information.

Based on our experiences, it is helpful to define three phases that are similar to those described by Stang (1982). Each of these three phases can

consist of several cycles of development, testing, evaluation and reflection (Figure 3).

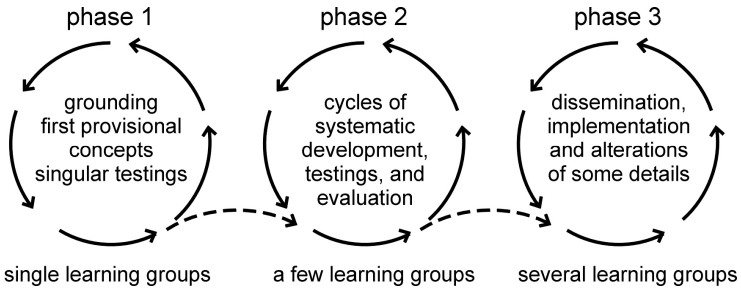


Figure 3. The three phases of the development process

The first phase is carried out with a small team. In this phase, the problem is considered, the relevant knowledge is analysed, and provisional concepts are developed. The concepts are then tested in single groups in order to decide whether the planned interventions have the potential to improve practice. In the second phase, a team is selected that consists of a group of teachers. The integration of teachers, who were not involved in the first phase, is the most important aspect of this phase. Their inclusion provides impartial feedback on the results of phase one. While working to motivate the teachers and justify the new approach, all group members are forced to rethink their assumptions. In the second phase, most of the work entails planning for changes, carrying them out and reflecting on the results. In the third phase, the main task is the dissemination of the results into practice. This also requires an evaluation of the new teaching methods and materials to determine whether or not they have been documented well enough for external practitioners to apply them without additional training.

The term "Action Research" implies that it is necessary to document and report the work and results continuously while the research process is taking place. These types of reports can help to improve practice outside the research team. Therefore, the discussions and interpretations should be well documented. The documentation may also include a description of the background and individual interests of the practitioners and researchers (Dickson & Green 2001). In the end, the reader will have to decide whether he or she feels that the described approaches are

authentic, relevant, credible and important, and whether or not they would be beneficial for their individual practice (Mayring 1999).

Action Research is carried out in a social setting with the objective of improving practice. Hence, it always influences practice and the persons involved. All of the persons involved should be aware of the influence they have on practice and on each other (cf. Tobin 1992). Thus, they should ensure that:

- the influences on practice do not harm any of the personal interests of the teachers or students involved, for example if the students are switching their teacher, class or school.
- it is possible to switch back to the conventional concept if necessary without undue disadvantages for students or teachers.
- the skills taught and the learning objectives of the lessons are at least as valuable as those taught using the conventional method, even though the nature of the skills and information can be different.
- all decisions made concerning changes in practice acknowledge the influences they have on practice.
- all data from real practice is handled confidentially, especially evaluative and assessment data.

3 From Teachers' Collaborative Work on Cooperative Learning towards the Development of Innovative Practices – An Example

An action research project of a group of roughly ten secondary level chemistry teachers has been underway in Germany since the summer of 1999. Originally accompanied by chemistry educators from the University of Dortmund, the project has been directed since 2004 by the University of Bremen. The starting point for establishing this kind of co-operation came from considerations that substantial curriculum development at the university level can only be realised in a give-and-take process based on teaching experience and existing research evidence (De Jong, 2000; Eilks & Ralle, 2002; McIntyre, 2005).

During the last ten years a large amount of evidence-based curricular structures and materials have been developed. Data which describe structures` and materials` implementation and effects were generated as well. From 2004 some of the teachers started to disseminate an overall implementation of the changed approaches via publication of a new school book series in co-operation with the accompanying university chemistry educator (Eilks et al., 2005). Reports about the working process of the group are available in Eilks (2003, 2007), Eilks and Markic (submitted), and Mamlok-Naaman and Eilks (submitted).

The focus of the group's work was the development, testing and evaluation of altered teaching approaches considering the particular nature of subject matter in lower secondary school chemistry teaching (e.g. Eilks, Möllering & Valanides, 2007). Later, it also covered the implementation of innovative teaching methods, especially in the areas of co-operative learning (e.g. Eilks, 2005), the reflective use of ICT (e.g. Eilks, Witteck & Pietzner, 2009), and in recent years it has moved towards curriculum development for a socio-critical and problem-oriented approach to chemistry teaching (e.g. Marks & Eilks, 2009).

One exemplary reflection should be used to highlight how the process of innovation can take place in this collaborative design if applied in a long-term perspective. This long-term perspective means working with a stable group of teachers on different projects of development from a similar field of innovation. The development of different lesson plans for cooperative learning environments in chemistry education should serve as an example. At the same time, the experiences reported are similar to those attained in other fields of this and related groups of PAR.

Science teaching in Germany, i. e. the practice of chemistry and physics lessons is predominantly characterized by quite content-driven and teacher-centred approaches (Gräber, 2002; Fischer et al., 2005). Nevertheless, since the 1990s more and more voices arose advocating a stronger inclusion of more student-active and cooperative methods into the science classrooms in Germany. One of the first methods to arouse broader interest in teachers' journals and in-service training was learning-at-stations (e.g. Eilks, 2002). Within this approach, the classroom is organized as a set of different stations offering different activities for the students to be worked on freely in a certain sequence

and within a given time framework. The tasks differ in levels of difficulty and allow for students' differentiation either through their own or the teacher's choice. Normally, the stations are worked on in small groups of 3-4 students. When the PAR-group began to acquaint themselves with cooperative learning, none of them had had any experience with learning-at-stations or related methods and only very few examples from chemistry had been described in the literature, cf. Eilks (2002). The experience that was described suggested that the method was motivating and allowed for more openness in teaching, but at the same time it was clear that the full potential of cooperative learning was not being realized because of the untrained students in combination with a lack of structure.

From the literature and under the guidance of the accompanying researcher the teachers familiarized themselves with the theory of cooperative learning (e.g. Johnson & Johnson, 1985) and the empirical evidence in its favour (e.g. Lazarowitz & Hertz-Lazarowitz, 1998). The group decided first to try out the more structured schemes of cooperative learning, i.e. the jigsaw classroom (Aronson, Blaney, Stephin, Sikes & Snapp, 1978). The format was applied to the topic of atomic structure, and the teachers in the groups had excellent experiences with this sample lesson, which became a leading pattern for future work (Leerhoff & Eilks, 2001; Eilks, 2005). The method was considered as being very fruitful, but nonetheless very demanding for the students due to their level and range of skills. Based on their growing awareness about the students' learning within cooperative setting, the teachers proposed preparing jigsaw lessons aimed at improving the students' skills in condensing information and explaining them to others. Different examples on the inside-outside-circle method were developed for this purpose, implemented and proved to be a good preparation exercise for the jigsaw method (Witteck, Most, Leerhoff & Eilks, 2004).

After having solved some of these smaller problems, the teachers asked whether other methods or combinations of different methods may lead to more openness while keeping the cooperative character of the lesson plans. Combinations of e.g. the jigsaw with the student teams and divisions method were developed (e.g. Markic & Eilks, 2006) and finally approaches for open lab-work instruction were combined with

cooperative learning within the framework of the learning company approach (e.g. Witteck & Eilks, 2006; Witteck, Most, Kienast & Eilks, 2007). The teachers moved away from simple adoption via theory-driven innovation into self-determined creation of a completely new structure. In the last step, beyond developing solutions addressing existing methodological issues, the teachers created a new step forward and contributed original innovations to the literature.

Gradually, the inclusion of cooperative learning into newly developed lesson plans of the group became an issue of lesser importance - these methods are now used as a matter of course. This can be seen in a whole set of lesson plans developed after the described experience. In this approach the general orientation of science education is put into question. The new project seeks to develop lesson plans that question the value of dealing with authentic and controversial socio-scientific issues for the development of real multidimensional scientific literacy. While selecting suitable topics and discussing this changed content and focus of science education, the internalized methods of cooperative learning became an everyday tool. All the lesson plans with this focus contain these elements (e.g. Marks, Bertram, & Eilks, 2008; Marks & Eilks, 2010) and the inclusion of cooperative learning became a constituting element of the developed theoretical framework for a socio-critical and problem-oriented approach to chemistry teaching (Marks & Eilks, 2009).

4 An Appraisal of the Effects in Practice and Teachers' CPD

There is a broad range of different interpretations of Action Research as a collaborative strategy for innovating teaching and learning processes. The most common criterion of diverse forms of action research is the role of the teacher (Grundy, 1982). Emerging from rather research-oriented models (Lewin, 1946), increasingly teacher-centred versions of action research were established in the educational sciences by the 1970s (Altrichter & Gstettner, 1993). Therefore, Grundy (1982) and Carr and Kemmis (1986) (see also or Kemmis, 1993) differentiated three different

modes of action research: technical, practical and emancipatory action research (Figure 4).

The three basic modes of Action Research are mainly measured by the overall degree of influence and responsibility of the practitioners, i.e. whether the practitioners contribute to important decisions concerning issues of content and methods. In one of our previous discussions of Grundy (Eilks & Ralle, 2003), we primarily used this classification as a structural model for deciding between different types of action research. With respect to carrying out and using experience in the project described above, however, Grundy's categorisation seems to lend itself more to a model of professional development (Markic & Eilks, submitted; Mamlok-Naaman & Eilks, submitted).

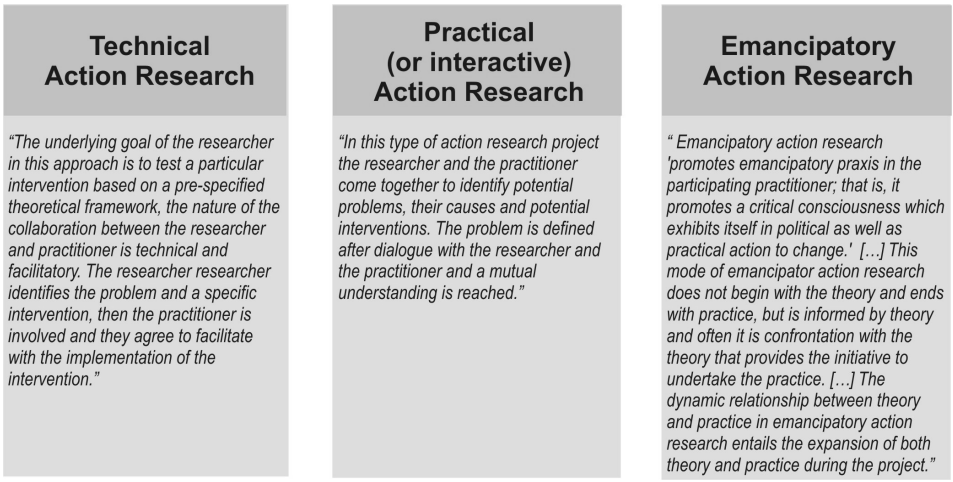


Figure 4. Three modes of action research in the means of Grundy (1982) illustrated by quotes from Masters (1995)

As Grundy (1982, p. 363) states, there can be movement between the different modes:

> *'The differences in the relationship between the participants and the source and scope of the guiding 'idea' can be traced to the question of power. In technical actions research it is the 'idea' which is the source of power for action and since the 'idea' often resides with the facilitator, it is the facilitator who controls power in the project. In practical action research the power is shared between a group of equal participants, but*

> *the emphasis is upon individual power of action. Power in emancipatory action research resides wholly within the group, not with the facilitator and not with individual within the group. It is often the change in power relationships within a group that causes a shift from one mode to another.'*

Our model was originally conceived as a model of practical action research. However, through monitoring of the teachers' reflections (Eilks, 2003, 2007; Markic & Eilks, submitted), it became similar to technical action research during the first twelve months. It is entirely possible that the dominance of the science educator, especially in the first year of the project, led to this situation. However, a slower approach at the start might have confused the clarity of the project's goals or even had a negative impact on the motivation of the participants. The structure of the co-operation in the second and third year increasingly became one of practical action research, while more and more recognising and stepping into the expanding role envisioned for them in the research model.

The systematic build-up process of developed and equal roles as envisioned in the model of PAR (Eilks & Ralle, 2002) was increasingly noticeable during this time of the project. This aided in the dismantling of obstacles and hierarchical attitudes between participants and researchers (cf. Noffke, 1994; Dickson & Green, 2001). It also led to better understanding between practitioners and the accompanying researchers. Even in the switch to this practical mode of action research there were clear signs of emerging teacher emancipation, at least with regard to authorities from outside the group, i.e. authors of textbooks and teachers' journals.

This trend became more obvious year by year. The teachers still rely on the guidance and external expertise of the science educator, but it has become a thoughtful decision instead of an insecure or stop-gap reaction. Now we can view the participants' increasing habit of self-reflection and growing decision-making abilities about when to follow and when to oppose particular changes as a successful contribution to the teachers' emancipation process.
If we take the usual procedures of innovation through syllabi or textbooks, this innovation is normally steered by outside sources.

Teachers often are very critical and choose to distance themselves from the process of innovation. This occurs because the practitioners have limited knowledge about the process and the reasons behind the curricular innovations. Emancipation from this outside regulation quite often happens through a teacher's refusal to act or obey orders.

Our project documents that attitude towards innovation can change drastically when introduced and aided by a participatory approach. When teachers are involved in long-term innovative research and when their voice is heard as described above, their attitudes and competencies can develop with respect to testing and implementation in a positive sense. This leads to teacher-based innovations stemming from their own convictions in the sense of a constructive rethinking of their ideas. Their *Pedagogical Content Knowledge* (PCK) develops in all dimensions as stated by Magnusson, Krajcik and Borko (1999): 1) orientation with respect to teaching, 2) knowledge of the curriculum, 3) knowledge of the testing of knowledge, 4) knowledge about learners and 5) knowledge about strategies of passing on knowledge. This is clear because the framework provided all sources for a change/growth of PCK as lined out by Grossman (1990): 1) observation of classes, both as a student and as a student teacher, 2) disciplinary education, 3) specific courses during teacher education, and 4) classroom teaching experience, and the one added later by Appleton and Kindt (1999) recommendations from trusted colleagues.

The teachers develop into the driving force and self-determined promoters of a change in teaching practices (Eilks, 2003; Eilks & Markic, submitted). This might be the biggest innovation such collaborative research and development has to offer. Here we can see essential steps of teachers' emancipation from the accompanying researcher and from authorities in general, which is a switch of behaviour from practical to emancipatory action research. Thus, Grundy's model might shift to a model of professional development within such designs (Figure 5) (Eilks & Markic, submitted).

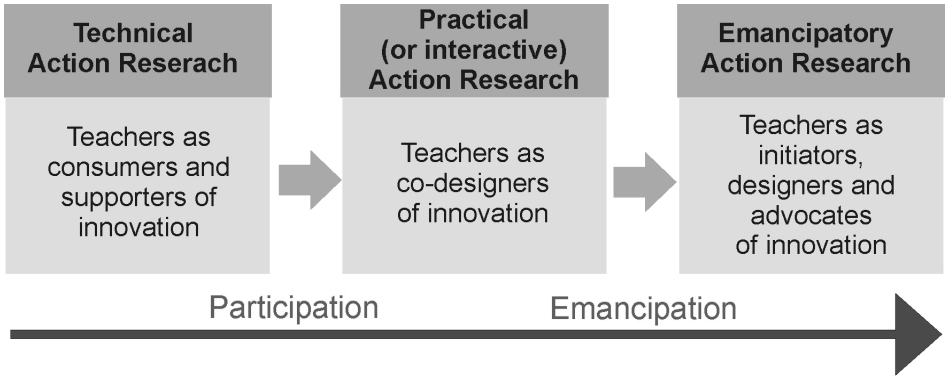


Figure 5. Structural development of action research

Even after ten years of collaborative work, teacher emancipation in the sense of total independence from university supervision has been purposely avoided by the teachers. The understanding that teachers and science educators stand on an equal footing and have different roles is deeply ingrained on both sides. The co-operation and simultaneous participation of both parties in their profession and teaching practices has led to wishes for intensified contact between schools and university. This was for quite simple and pragmatic reasons such as access to information and resources, and an understanding of the different, but complementary, types of expertise of the researchers and practitioners in the project (McIntyre, 2005).

The project introduced here seems to prove Huberman's (1993) call for sustained interaction between research and practice as the basis of effective innovation. The process-based interaction of the four domains of the *Interconnected Model of Teachers' Professional Growth* (IMTPG) by Clarke and Hollingsworth (2002) seems to be systematically carried out: (i) foreknowledge and needs of the participants (the personal domain), (ii) influences from empirical and curricular teaching/learning research (the external domain), (iii) testing in authentic classroom situations (the domain of practical relevance) and (iv) the recording of and reflection upon the effects of changed practice (the domain of consequences). This sustained interaction of the four domains taken from the IMTPG seems fundamental for the success and productivity of this kind of classroom innovation under inclusion of teachers.

The research project described in this paper, however, also had further effects with regard to stronger teacher professionalization. The teachers changed their views, PCK and attitudes about teaching and learning. They developed competencies in the structuring and critical examination of teaching practices. Furthermore, they developed new attitudes in view of their own teaching approach and the necessity of innovation and translated these into action with self-confidence. Such long-term interaction allows us glimpses into the interplay between an emerging PCK of the in-service teachers and their personal actions, an area in which large research deficits still exist (Calderhead, 1996). With respect to the five PCK domains defined by Magnusson et al. (1999), we found that our integrated approach covered all five areas: 1) a common orientation in regard to teaching occurs, 2) the original curriculum is reflected upon, consciously changed and further developed, 3) aids given through evaluation add to competency in the area of knowledge inspection, 4) knowledge about learners is expanded through dealing with empirical teaching/learning research and personal self-reflection, and 5) knowledge of strategies for conveying concepts to others develops with the creation of new teaching/learning environments (see above).

Experiences as documented here must allow questions about the potential of traditional top-down models of innovation, whose efficiency has repeatedly been called into question (e.g. Smith & Neale, 1989). Such methods often have only selective points of approachability, even if they take the form of a series of lectures or are offered as courses lasting several days. The temporal horizon shown by this study should serve as a reason to both re-question and re-evaluate the selective approach – even if it is repeated – or the constantly discussed multiplicator model of the past. Reasons for debating the efficiency of off-and-on or sporadic training methods for in-service education become clear after reading the above-described process. Even the multiplicator model with its short cycles of training seems problematic if no sufficient supervision by professional and experienced caretakers is given to younger generations of educators. How much time future multiplicators require to achieve a permanent change in their personal attitudes and growth of their PCK depends strongly on each individual case. The model discussed in this chapter, however, demonstrates clearly that multiplication taking place too early hides the danger of innovations not being implemented in the

intended way. In this case, we have only the very limited possibility of a top-down innovation based on pre-produced materials and ideas (Tobin & Dawson, 1992). One question arising from the above-described case study is how effective such materials can be for sustainable changes if they are not coupled with believable and authentic – and in the best case, personal – experiences.

Of course, the model presented here has certain natural limitations. University science education groups can only utilise such intensive participation models in selected situations. The carriers of innovation in educational systems must ask themselves whether such intensive supervision might represent one possible way to introduce changes in teaching practices sustainably, one which might just be worth the investment.

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ACADEMIC TEACHER AT THE CROSSROADS OF INNOVATION HIGHWAYS

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SUMMARY

Every academic teacher is influenced by two streams of innovations: one related to general processes occurring in the art of pedagogy and organizational changes in higher education (such as the Bologna Process in Europe), and the other connected with changes in his/her subject area. These two strands influence each other, which is particularly well seen in the field of chemistry. The Bologna "wind of change" favors national and institutional reforms, promotes quality culture, and accelerates a transition from teacher-centered to learner-centered education. At European, national and institutional level, new tools and procedures are tested and introduced, including motivation mechanisms to promote excellence in teaching. Networking is a powerful tool to generate new quality in academic life and practice. The community of academics in chemistry is well organized at the European level: integration processes in academic chemistry teaching started around 1988 with the ECTS pilot project (originally 15 institutions) and culminated in ECTN (around 150 institutions); now the integration encompasses also chemical engineering, within the pan-European EC_2E_2N - European Chemistry and Chemical Engineering Education Network. ECTN members participated actively in the TUNING project and Chemistry Eurolabels serve as model examples of international subject area accreditation. The Faculty of Chemistry at the Jagiellonian University (FCJU) in Krakow belongs to the most dynamic Jagiellonian University units; it was also the first Polish institution to join ECTN (in 1997). Being at the crossroads of the two streams of innovation (pedagogy + chemistry), it is an "innovative, learning organization". In line with the old maxim in chemistry "If you're not part of the solution, you're part of the precipitate." we advocate stronger involvement of 'common academic folk" in on-going change processes.

KEY WORDS: Academic teachers, Staff development, ECTN, HEA

1 Introduction

Every academic teacher is influenced by two streams of innovations: one related to general processes occurring in the art of pedagogy and organizational changes in higher education (such as the Bologna Process in Europe), and the other connected with changes in his/her subject area. These two strands influence each other. Pedagogical innovations may concern many aspects of the education process, e.g. curriculum, teaching & learning environment, teaching & learning methods, assessment/evaluation methods, teacher's and student's work organisation. Such innovations may be applied at various scales and levels. (Figure 1)

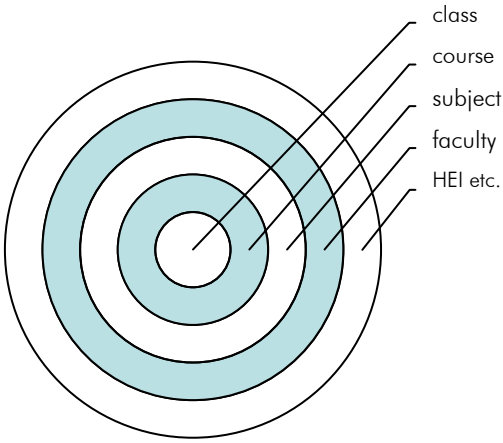


Figure 1. Organisational levels

Implementation of innovations is an indispensable element of quality assurance and enhancement. When executing this process, some questions arise:

- Ways of transferring pedagogical innovations into different subject fields.
- Teachers' views on innovation, the school climate for effective innovation.
- Teachers' qualification for innovation of their own pedagogical practice.
- Ways of encouraging teachers' and students' innovations.

These questions become particularly important when educating people at university level where new scientific knowledge in a given subject is implemented relatively quickly and is welcomed by scientific and academic communities. However, the implementation of pedagogical innovations takes place rather rarely, slowly, and is often met with distrust.

2 Innovation in Higher Education

The Bologna "wind of change" favors national and institutional reforms, promotes quality culture, and accelerates transition from teacher-centered to learner-centered education. At European, national and institutional level, new tools and procedures are tested and introduced, including motivation mechanisms to promote excellence in teaching. In order to characterize the complexity of the European Higher Education Area, a model of **„Bologna Tetrahedron" - B4H** is proposed (Frankowicz, 2006)**.** The following dimensions are suggested to 'geometrise' the EHEA:

S1 ("State"): national and supranational structures (such as the European Commission) determining legislative frameworks for education

S2 ("Subject"): area of research/study, profession, as well as related organizational structures (professional organizations, learned societies etc.)

S3 ("School"): higher education institutions and their structures and associations (HEI's governing bodies, conferences of rectors etc.)

S4 ("Society"): environment of HE: labour market, society at large, local community etc.

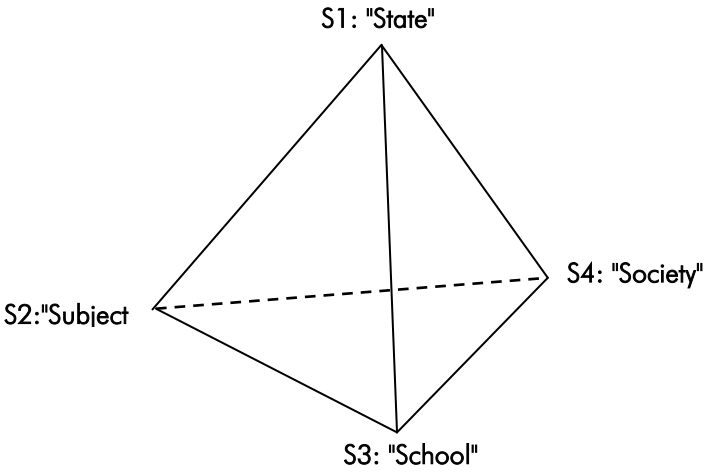


Figure 2. "Bologna Tetrahedron"

The B4H model applied to the analysis of the innovation processes in higher education identifies four areas for analysis:

S1: Legal framework enabling innovations
S2: New curricula, new T&L methods
S3: New organisation of T&L
S4: Innovative cooperation of all stakeholders to build the knowledge society

Basic questions posed by students can be also reduced to four basic problems:

S1: Will I get a valid diploma?
S2: Will I learn modern and useful knowledge?
S3: Will I have an appropriate learning environment?
S4: Will I enhance my employability and develop my personality?

If some changes in a complex system (and any higher education institution is complex by default) are implemented, they can influence all of its elements, as well as its interactions with the external environment; thus the idea of **Complex Adaptive Systems** (CAS) (Gell-Mann 1995; Axelrod, Cohen 2000) can be applied.

Universities are perfect examples of CAS. As it was observed (Frankowicz, Kozielska 2004), a university is even more complex than an

industrial enterprise; whereas industry is focused on creating products and thereby generating profit, the university is multifunctional. It operates as a centre for education, a research facility, and it interacts with society at large. Whilst its research can influence public policy, the university itself also responds to social change, for example by changing its offer of degree programmes, by the process of internationalisation and by staff development. The CAS approach has been recently applied (Pyla 2005) to describe implementation of ECTS at the Jagiellonian University.

3 Ways of creating, transferring and dissemination of innovations

3.1 Networking

Networking is a powerful tool to generate new quality in academic life and practice. Academic networks can be divided into various categories. Frankowicz (2005) distinguishes:

i) ***"academic clubs"*** – networks characterised by particular selection criteria, such as: excellence and tradition (Coimbra Group), universities in capital cities (UNICA) or links to "Route to Santiago" and its cultural dimension (Compostela Group)

ii) ***thematic networks*** (in a broad sense), i.e. networks centered around specific subjects areas (chemistry, languages, arts, engineering etc.) or topics (e-learning, university governance etc.). Examples of such networks are: ECTN, ESTIA NET, TREE, EUCEN. These networks have a tendency to "cluster" around broader domains and form "archipelagos" (such as TECHNO TN).

iii) ***regional networks*** including institutions in specific geographic areas. The examples of such networks are: Network of Mediterranean Universities, Black Sea University Network, Barents Sea Network, Alpe-Adria, Danube Rectors Conference and the just emerging Academic Network for Central and Eastern Europe (ANforCEE).

Bringing innovations into effect requires co-operation of many parties. A good example is HERN - **Higher Education Reform Network** – a socio-economic thematic network funded by the 5th Framework Programme in years 2001-2004**.** The Higher Education Reform Network has been established to explore how different cultural contexts influence the procedures for the governance, decision-making, quality assurance and accountability of higher education with particular reference to issues of gender, disability, access and inclusion (Frankowicz et al., 2007). It has aimed to help improve European integration strategies for the future. The partners profit from the 'heterogeneity' of the HERN consortium:

- Partner institutions are of different types and sizes (Ministry, University, Department...)
- Contact persons are specialists in various fields (pedagogy, sociology, chemistry, political sciences, informatics... etc.)
- Contact persons hold different positions (vice rector, administrative officer, academic teacher ... etc.)

Such diversity could lead to new quality. The conference organized in the framework of HERN in September 2006 hosted three types of audiences:

- researchers/experts in socio-economics (i.e. people who create new knowledge, ideas/recommendations and advice),
- decision makers (politicians), mass media etc. (i.e. people who make decisions and influence public opinion),
- specialists/practitioners: teachers, trainers, counselors, persons working in the employment sector etc. (i.e. people who implement the programmes of social, educational and employment policy).

Founded in September 1996, **European Chemistry Thematic Network** (Frankowicz, 2007) has not only become a driving force of educational reforms not only for the chemical community but also serves as a beacon for other disciplines. ECTN thematic networks were functioning within three year grant periods until 2009. At present the network has expanded its activity to engineers and has been named EC2E2N (**European Chemistry and Chemical Engineering Education project)**. EC2E2N has about 118 members from 32 countries.

The project[1]:

- will produce innovative products and processes, such as a virtual campus, quality labels for teacher training programmes, a Eurolecturer qualification, training tools for languages in specific areas (English, German, Spanish, French and Italian), and a training course for generic skills for third cycle students.
- will help promote entrepreneurship by proposing a curriculum for entrepreneurial skills and developing the tools for a network of entrepreneurs.
- will facilitate the comparability of degree programmes across Europe by creating a common database of programmes across Europe, by proposing a common framework for chemistry teacher training, and developing the tools for European quality labels for these programmes.
- will increase the attractiveness of studies in chemistry and chemical engineering by evaluating activities carried out across Europe for that purpose. It will also provide teaching and training materials for school teachers and pupils to explain the changes taking place in HE as a result of the Bologna process.
- will support innovative ICT-based products by developing a virtual campus, by producing on-line language courses for chemists and engineers, on-line materials for lecturer competences, and on-line tests on fundamentals and in specific areas at the interface of chemistry and chemical engineering in English, French, German, Spanish and Italian.
- will enhance the interaction between chemists and chemical engineers in academia, support programmes at the interface of these areas, and increase the employability of graduates in those fields.

The 'core team" of ECTN was formed by ECTS pilot project participants (started in 1988) and the creation of the network was preceded by a pan-European Erasmus congress "Chemistry in Europe" devoted to the comparison and analysis of chemistry curricula in 17 European

[1] EC2E2N Web page, http://ectn-assoc.cpe.fr/network/ectn5_EC2E2N.htm accessed 10.02.2009

countries (Frankowicz et al,2006). One of first ECTN activities was the elaboration of "core curricula" proposals for main areas of chemistry; it was followed by the "EChemTest" project aiming at building of electronic system of chemistry tests at different levels (starting from basic pre-university up to advanced one). In 2002, the European Chemistry Thematic Network Association (ECTNA) has been registered in Brussels as a legal entity. At present, it consists of about 120 members from 30 countries (not only HEIs, but also chemical societies and other organizations).

Academic teachers work in groups and share their experience, thoughts, the results of innovations implemented in the local environment, and then they jointly work out recommendations or reports. The subject matter the work groups are involved with changes every two to three years (along with changing financing from the next project: ECTN 1, ECTN 2). Some of the topics covered so far include[2]: *Communication and Management Skills, Chemistry and the Environment , Catalysis and New Materials, Post-University Training for Industrial Chemists, Teaching and Learning: Practical Skills, The Image of Chemistry, Core Chemistry: Teaching and Learning: Practical Skills, Green and Sustainable Chemistry, Chemical Education using Multimedia, Core Chemistry for the Future Postgraduate Education and Training, Biological Chemistry, Remediation (environmental), Industrial placements, Chemistry and Cultural Heritage, Evaluation of Core ChemistryTuning Educational Structures in Europe.* In the ECTN 3 project new groups were formed: *Rare chemistry, Links with Schools, Newly Appointed University Chemistry Teaching Staff, Teaching/Teachers Assessment by Students European Dimension in the 2nd and 3rd Cycle Studies*. In the last project (ECTN 4) the topics were: *The employability of chemistry graduates***, *Innovation in Chemistry Teaching***, *Internet-based tests in biological chemistry, and Project Information Management.*

The thematic sub-groups in the *Innovation in Chemistry Teaching group* presented themselves as follows:

- *Modern theories of learning and the need for innovation in university chemistry education*

[2] ECTN Web page, http://ectn-assoc.cpe.fr/network/wg_chrono.htm accessed 10.02.2020

- *Problem- and context based approaches within university chemistry education*
- *Research-based teaching*
- *From forming groups to cooperative learning*
- *Making students the teachers - Peer-tutoring in a lab environment*
- *Dealing with chemicals and experiments in a different style – including risk assessment, environmental issues and micro-scale approaches*
- *Learning beyond the lecture hall*
- *Online support and online assessment of lectures and lab-work*
- *Multimedia and visualisation*
- *Training programs for newly appointed teaching staff*

All these groups jointly published their work in a book (Eilks & Byers, 2009).

The chemistry community responds promptly to Bologna challenges. The members of the Chemistry Subject Area group in the **Tuning Project** have elaborated a set of so-called "Budapest descriptors" for chemistry graduates based on the generic "Dublin" descriptors developed by members of the Joint Quality Initiative) and a framework for a first cycle qualification in chemistry, the "Eurobachelor" (Frankowicz, 2007).

3.2 Lifelong teacher learning as a principal factor in implementation of innovation

To implement innovations, a teacher should possess knowledge, abilities and the right attitude towards them. The teaching quality guidelines were set for the European Higher Education Area (EHEA) by the European Network for Quality Assurance (ENQA). These stipulate that "teaching staff should be given opportunities to develop and extend their teaching capacity" and that "institutions should provide poor teachers with opportunities to improve their skills to an acceptable level" (Standards, 2005).

It is worth mentioning here that according to the research (Yates et al, 2009) conducted in most Western European countries (particularly in North-Western ones) universities have special organisational units

which are involved in the continuous improvement of staff didactic skills and qualifications, making the employees familiar with the most recent achievements and innovations in the science of pedagogy. The units are called **"Staff Development Office".** In contrast, most of the Eastern and Southern European universities leave this problem in the employees' hands without offering them any assistance.
Taking into account the above mentioned facts, other ways which could be used for conveying knowledge to academic teachers, mastering skills and building a more open attitude seem to be worth listing.

Sharing experience in this area between universities is indispensable. **The Tempus Program** has enabled EU countries, and presently candidate countries as well, to implement a number of innovative solutions which turned out to be useful elsewhere. This was possible through co-financing of equipment purchases (lab equipment, computers), publication of manuals, textbooks, training of academic teachers, study visits.

Since 2005, a Polish initiative of **international conferences** under the banner of the European Variety In Chemistry Education have been taking place, specifically targeting academic teachers (2005 – Krakow[3], 2007- Prague[4], 2009 - Manchester[5]). The aim of these conferences is to share examples of good practice in didactic innovations. The conference was devoted to practical aspects of chemical education at tertiary (university) level. It has provided a forum (about 100 participants from about 20 countries) for an exchange of ideas related to teaching and learning chemistry at degree level, the sharing of good practice and innovation, and the dissemination of outcomes of pedagogic research as it relates to chemistry at university level in Europe. The objective of the conference was to improve the quality of chemistry education provided to students, as well as launching international cooperation among individual lecturers and their universities, which could lead to joint projects and exchange of staff and students in the future. An

[3] Conference Web page http://www.chemia.uj.edu.pl/~eurovariety/html/index.html accessed 10.02.2010
[4] Conference Web page http://web.natur.cuni.cz/eurovariety/ accessed 10.02.2010
[5] Conference Web page http://www.heacademy.ac.uk/eurovariety accessed 10.02.2010

international consortium of universities applying commonly to the programme *Erasmus Mundus* was proposed.

The Newly Appointed University Chemistry Teaching Staff* ECTN *Group organised two summer schools for new employees – academic teachers in Malta in 2005 and 2007. The international staff was composed of the representatives of various European universities from Nottingham to Lyon, and from Sofia to Kraków. Classes were conducted in the form of workshops. The subject matter included: teaching in a context and problem teaching, training in practical skills, the role and importance of the lab, training in presentation and communication skills, evaluation, the role of feedback, the European dimension of chemistry education (projects, thematic networks, possibilities of gaining funds), differentiation of students with respect to gender, mother tongue, intellectual capacity, special needs, didactic means and Internet resources.

4 The Polish context

The promotion and support of innovative pedagogic and didactic solutions in higher education in Poland is taking place in many ways. The Polish chemistry community has actively participated in the development of a national curricular framework and educational standards. Starting from 1991, **annual conferences of deans of Polish chemistry faculties** have been organized. Within this activity deans familiarise themselves with both the Europe-wide solutions (e.g Tuning project) and good practice examples from within Poland (e.g the Technical University of Gdansk). Then this knowledge and incentive for changes is passed on into local environments. Academic teachers have opportunity to learn about and share didactic innovations and achievements in two Polish nationwide conferences: in the **Polish Chemical Society annual meeting** chemistry education division's debates (e.g. Milczarek et al., 2006) and those of **ICTchem** 2007[6] and

[6] Conference Web page http://www.chemia.uj.edu.pl/~ictchem/ accessed 10.02.2010

2008[7], dedicated to the application of information and communication technology in the education process and chemistry research.

4.1 The Case of the Jagiellonian University

The oldest university in Poland (established in 1364), the Jagiellonian University has always been the forepost of academic reforms (Frankowicz et al., 2005).

In the last years, to stimulate good practice in teaching and promote innovations, the so-called "**Ars Docendi**" package has been introduced. It consists of:

- "ARS DOCENDI" Prize – the prize for an outstanding academic teacher
- "ARS DOCENDI" grants system – a system of small grants promoting educational innovations (such as courses in foreign languages, introduction of ICT, new organizational solutions etc.)
- "ARS DOCENDI" lectures – organized for doctoral students, concerning the most important and interesting topics in HE didactics and management. The resulting contact networks function on after a course is completed and this constitutes a support for the participants of the course in implementing the innovations they became acquainted with during the course.

In the **evaluation of the didactic achievements** of an employee (university) both the assessment of students and the extent of the innovations being implemented is taken into consideration. This is one of the methods of encouraging teachers to apply innovations.

4.2 Rector's Commission for Development of Didactics and Quality Assurance

It is a standing commission which first appeared in 2002. In its present shape (as determined by the Rector's order from November 2008) it consists of four working groups:

- WG for design and implementation of the QA system,

[7] Conference Web page http://www.chemia.uj.edu.pl/ictchem/ accessed 10.02.2010

- WG for internationalization of studies,
- WG for identification of new study areas and development of innovative teaching and learning methods,
- WG for 3rd cycle (doctoral) studies.

Each WG works autonomously, but there are regular meetings of WG leaders with the Vice Rector for Educational Affairs to correlate all strands and to decide on the schedule of implementation of new solutions. The important feature of the Commission is the active participation of university administrative staff.

4.3 The Interdisciplinary Centre of Research on Higher Education

Poland was the first country from the Eastern block which started political and social transformations. The 1990 Act on Higher Education was the first important legal act of the non-Communist parliament and government. After 1990, Polish higher education started to develop very rapidly; from less than 400,000 students and 100 state HEIs up to over 400 institutions and around 2 million students. The characteristic feature of early 90s was the increased diversity (even divergence). First, over 300 non-state HEIS appeared (by now they cater to about one third of students). Second, in the realm of curricular development various HEIs (and even various faculties/departments within the same HEI) experimented with different study models (both for the structure as for the curricular contents). Depending on particular experiences of local academic decision makers and curricular developers, various solutions imported from different Western countries have been implemented.

Quite early the question arose whether all the innovations implemented at the time serve students' education and the university development well. One indispensable element was to be added: investigation of the results of these innovations. This problem became the task of the Research Centre for Higher Education System brought into being at the Jagiellonian University in Krakow.

The Centre will be affiliated to the Faculty of Management and Human Communication, but will have an interdisciplinary character. It will consist not only of research groups belonging to it at the institutional level, but will also have a pool of 'associated" research groups from other faculties.

For the Interdisciplinary Centre of the Research on Higher Education, the following **strategic objectives** were adopted:

- to monitor, coordinate and initiate activities related to the implementation of the Bologna Process at the institutional, regional and national level;
- to promote quality culture; develop QA methodologies, tools and procedures
- promote fast information exchange between all subjects interested in problems of the higher education and research,
- conduct research, training, design and consulting activity in the domain of higher education,
- express opinions and exert influence on the HE and science policy

To realize the objectives mentioned above, the following **activities** will be undertaken:

- conducting research work,
- issuing opinions and recommendations,
- creating databases of domestic and foreign experts working in the area of higher education research;
- assisting in the organization of research teams dealing with improving higher education and scientific activity
- organizing conferences, seminars and workshops;
- provide training, both at the initiative of the Centre and on demand of external institutions,
- publishing books, the bulletin of the Centre and research reports;
- cooperation with other centres and institutions working in the area, networking, promoting joint actions,
- organizing informal meetings for staff, doctoral students and students enabling a free exchange of ideas and opinions concerning higher education.

JU-CHER has so far organized a national seminar on university reforms and designed and implemented an information package for deans - containing national and university regulations and Bologna information materials. It is also looking towards the future. According to Pink (2005), in the next 50 years we will transition from the information age to the conceptual age, where human creativity and empathy will play a major

role in the social and economic development. JU-CHER has started cooperation with the University of Central Florida to explore the future of higher education in the context of unprecedented progress in science, engineering and technology, and to develop new paradigms for higher education systems, their delivery, administration, and funding in the Conceptual Age.

4.4 Faculty of Chemistry JU

The Faculty of Chemistry at the Jagiellonian University (FCJU) in Krakow belongs to the most dynamic Jagiellonian University units; it was also the first Polish institution to join ECTN (in 1997). Being at the crossroads of the two streams of innovation (pedagogy + chemistry), it is an "innovative, learning organization". Innovations implemented at the faculty deal with various aspects of academic teacher work beginning with changes in curricula, introducing the credit transfer system (Tempus projects: CME, CHECTS, DEPES), basing work on learning outcomes, early introduction of evaluation of teachers' work by students, via novel topics (forensic chemistry – Tempus project, solid state chemistry –SOLID Leonardo da Vinci Project, chemical technology –Chemepass project), and in the end a tight collaboration with industry and other stakeholders (FACE –Leonardo da Vinci project, CITIES Socrates Comenius Project) and so on.

Academic staff and PhD students within this faculty have traditionally been able to extend their didactic experience, develop teaching skills and become familiar with pedagogical innovations in the following ways (Yates et al, 2009):

- by participating in full-time courses or events organised as part of the series *Selected Problems of Chemistry Didactics in Tertiary Education*, which have been run since 2001 and in a residential form since 2005
- by participating in *Ars Docendi* courses organised by the university's Teaching Department for all the university's employees since 2004
- by participating in open sessions of the Didactic Commission of the Faculty Council
- by attending lectures about teaching at tertiary level given by external experts

- by participating in national and international conferences organised by the Faculty
- by becoming acquainted with other educational systems through participation in staff exchange programmes such as the EU's Socrates-Erasmus.

The **course** ***Selected Problems of Chemistry Didactics in Tertiary Education*** consists of classes on general subjects, conducted by a psychologist or pedagogue, and on discipline-specific issues, conducted by a member of the Department of Chemistry Education. In both cases they are supplemented by material provided by academic chemistry teachers. The materials developed as part of course assessments - a scenario of innovative classes, where teaching methods are used which promote active learning - are typically presented at national and international conferences (Wietecha et al, 2003; Maciejowska et al., 2007; Białas, 2006). In implementing innovations, teachers can use the methodology and examples described in a manual/**handbook** developed especially for them**.** (Maciejowska, 2009)

5 Conclusions, systematic and organizational changes required for quality implementation of innovation in the pedagogical process

Implementation of innovations is the necessary condition for improving teaching standards.

Encouraging teachers to such an activity and providing them with indispensable knowledge and skills is possible only by conducting lifelong learning. This applies also to academic teachers.

Supporting innovation implementation has to take place at all levels: starting from the university faculty, trough the university as a whole, to ministries, international associations and organisational units. The precondition for success is communication and information flow in both directions: bottom up and top down. It is important that various "bottom-up" activities receive a strong methodological and logistic support; otherwise they may dissipate. Collaborative activities lead to

concrete practical results (such as curricular standards and curriculum design methodology). The academic community of tertiary teachers of chemistry is a good example. An academic teacher who is not the author of a given innovation will incorporate it into his/her practice more easily if he/she understands it better and accepts the purpose of such a change. Although this is well known and proved in pedagogy and management domain, it is unfortunately extremely rarely applied in practice. In conclusion, referring to the old chemical maxim "If you're not part of the solution, you're part of the precipitate", we advocate stronger involvement of 'common academic folk" in on-going change processes.

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USING A TRANSFORMATIVE MODEL OF INTEGRATING TECHNOLOGY AND PEER COACHING TO DEVELOP »TPCK« OF PRE-SERVICE SCIENCE TEACHERS

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ABSTRACT

This study examined the impact of a transformative model of integrating technology and peer coaching for developing pedagogical content knowledge of pre-service science teachers. A TPCK-COPR model and an online system were designed to restructure science teacher education courses. Participants of this study included a single instructor and a group of pre-service teachers (n=12). The study used self-assessment, peer assessment and expert assessment for assessing pre-service science teachers' competencies to teach with technology. The results showed that there were significant differences in "Total TPCK competency" between the two tasks. This study expanded four views, namely, the comprehensive, imitative, transformative and integrative views to explore the impact of TPCK. The model could help pre-service teachers develop technological pedagogical methods and strategies of integrating subject-matter knowledge into science lessons, and further enhanced their TPCK.

KEY WORDS: Computer-assisted learning; PCK; Peer-coaching; Pre-service science teachers; TPCK

1 Introduction

A newly integrated curriculum scheme was implemented in primary and secondary schools of Taiwan in 2001. Such reform will inevitably

affect the design and instruction of teacher education courses in universities. New science teachers should be equipped with the ability to integrate and design the curriculum and technology for innovative teaching (Jang, 2006; National Research Council, 1996). Current teacher education courses for pre-service teachers in Taiwan can be classified into two main categories: courses on subject-matter knowledge and those on professional knowledge of education (Jang, 2007). However, many studies have pointed out that many pre-service teachers who study science teaching knowledge, theories, methods and skills actually cannot cope with the real teaching situation (Jang, 2007; Hashweh, 2005; Tuan, 1996). It has also been reported that the success of science teaching depends not only on the teachers' subject-matter knowledge but also on their personal understanding of students' prior knowledge and learning difficulty (Grossman, 1990; Lederman, Gess-Newsome & Latz, 1994). In addition, other factors of success include their own teaching methods and strategies, curriculum knowledge, educational situation, goal and value (Shulman, 1987). In particular, the pedagogical content knowledge (PCK) of pre-service teachers is the main issue of the current teacher education revolution (De Jong, Van Driel & Verloop, 2005; Grossman, 1990; Shulman, 1986).

Shulman's notion of PCK has attracted much attention and has been interpreted in different ways (Geddis, Onslow, Beynon & Oesch, 1993; Grossman, 1990). The foundation of science PCK is thought to be the amalgam of a teacher's pedagogy and understanding of science content such that it influences their teaching in ways that will best engender students' science learning for understanding. Initially, pre-service teachers separate subject-matter knowledge from general pedagogical knowledge. These types of knowledge are, however, being integrated as a result of teaching experiences. By getting acquainted with the specific conceptions and ways, pre-service teachers may start to restructure their subject-matter knowledge into a form that enables productive communication with their students (Lederman, Gess-Newsome and Latz, 1994). According to Lederman, Gess- Newsome and Latz (1994), the development of PCK among pre-service science teachers is promoted by the constant use of subject-matter knowledge in different teaching situations. Many scholars suggest that PCK is developed through an integrative process rooted in classroom practice, and that

PCK guides the teachers' actions when dealing with a specific subject matter in the classroom.

On the other hand, how to integrate technology into pre-service science teachers' PCK is another important issue. In contrast to the simple view of technology (Angeli, 2005; Davis & Falba, 2002; Jang, 2008a, 2008b; Watts-Taffe, Gwinn, Johnson & Horn, 2003), the main issue emphasizes the connections and interactions between and among content, pedagogy, and technology (Mishra & Koehler, 2006; Niess, 2005). For technology to become an integral tool for learning, pre-service science teachers must develop an overarching conception of their subject matter with respect to technology and what it means to teach with technology—a technological pedagogical content knowledge (TPCK). In this case, knowledge about content (C), pedagogy (P), and technology (T) is central for developing good teaching. However, rather than treating these as separate bodies of knowledge, this model emphasizes particularly the complex interplay of these three bodies of knowledge. TPCK is the integration of the development of subject-matter knowledge with that of technology and of teaching and learning knowledge (Niess, 2005). However, the current teacher education programs often offer one basic technology course that pre-service teachers are required to take (Pope, Hare & Howard. 2005; Willis & Sujo de Montes, 2002). This basic technology course should be the foundation for integrated activities in all courses (Pope, Hare & Howard, 2005). Pre-service teachers learn much about technology outside both the development of their subject-matter knowledge and the development of their teaching and learning knowledge. Similarly, they learn about learning and teaching outside both the subject matter and technology knowledge. In fact, pre-service teachers often learn about teaching and learning with technology in a more generic manner unconnected with the development of their subject-matter knowledge (Doering, Hughes & Huffman, 2003; Kim, Hannafin & Bryan, 2007; Lewis, 2006; Rosaen et al., 2003; Vannatta & Fordham, 2004).

Many related studies indicated that the instructional model related to teaching experience was important for PCK development (De Jong, Van Driel & Verloop, 2005; Loughran, Mulhall & Berry, 2004; Van Dijk & Kattmann, 2007; Van Driel, De Jong & Verloop, 2002). However, there were few empirical researches integrating technology into the PCK of pre-service science teachers (Angeli & Valanides, 2009; Koehler, Mishra

& Yahya, 2007; Mishra & Koehler, 2006; Niess, 2005). The purpose of this study was to develop a transformative model for enhancing the TPCK of pre-service teachers in a science teacher education course.

2 Theoretical framework

2.1 Pre-service science teachers' PCK with technology

The impact of constructivist epistemology seems to be important in PCK. As constructivism emphasizes the role of previous experience in knowledge construction processes, it is not surprising that teachers' knowledge is studied in relation to their practice in research from this point of view. Shulman (1987) regarded PCK as the knowledge base for teaching. This knowledge base comprises seven categories, three of which are content related (subject-matter knowledge, PCK, and curriculum knowledge). The other four categories refer to general pedagogy, learners and their characteristics, educational contexts, and educational purposes. The crucial factor in this development of PCK is, obviously, teaching experience (De Jong, Van Driel & Verloop, 2005; Gess-Newsome & Lederman, 1993; Loughran, Mulhall & Berry, 2004; Van Driel, De Jong & Verloop, 2002). PCK involves the transformation of other types of knowledge (subject matter knowledge, pedagogical knowledge, and knowledge of context) into viable instruction (Abell, 2008), so that it can be used effectively and flexibly in the communication process between teachers and learners during classroom practice. Science teachers' PCK is deeply personal, highly contextualized and influenced by teaching interaction and experience (De Jong, Van Driel & Verloop, 2005; Van Dijk & Kattmann, 2007; Van Driel, Beijaard & Verloop, 2001). Mulholland and Wallace (2005) suggested that science teachers' PCK requires the longitudinal development of experience as they develop from novices into experienced teachers. Van Driel, De Jong & Verloop (2002) investigated the development of PCK within a group of 12 pre-service chemistry teachers and claimed that the subject-matter knowledge was a prerequisite for the development of PCK and that PCK developed in the actual teaching experience of teachers. Thus, pre-service teachers may derive PCK from their own teaching practice as well as from schooling activities. Many scholars suggest that PCK is developed through an integrative process rooted in classroom practice,

and that PCK guides the teachers' actions when dealing with a specific subject matter in the classroom.

In previous studies, science education researchers have emphasized the importance of supporting professional development of pre-service teachers for technology integration (Flick & Bell, 2000; Jang, 2008a, 2008b; Kim, Hannafin & Bryan, 2007). In the communities of teaching practice, electronic dialogue on classroom issues has been shown to support effective reflection and shared practical knowledge among pre-service teachers (Edens, 2000; Jang, 2008a; Levin, 1999). The characteristics of online communities fit the PCK development of many pre-service teachers. The community-support needs expressed by teachers included overcoming isolation from and sharing experiences with peers, providing equal access to PCK development opportunities and ongoing support for the change process, sharing tools for professional discourse, and allowing for asynchronous communication which is more amenable to in-depth, reflective conversation (Dalgarno & Colgan, 2007; Shotsberger, 2000). This approach is socially constructivist in nature because learning depends upon constructing personal knowledge for teaching through social interactions in a community of practice (Jang, 2007; Vygotsky, 1978). PCK is collaboratively constructed between individuals whence it can be appropriated by each individual. This form of thinking and dialogue among pre-service teachers aligns reflection closely with practice. Pre-service teachers posted reflective thoughts and queries on personal practice to a specified Internet site for practical feedback from others in the community. Electronic forums help support this sharing and reflection between pre-service teachers that in the past could only occur in face-to-face meetings (Jang, 2008a; Upitis & Russell, 1998).

3 Technological pedagogical content knowledge

TPCK emphasizes the connections and interactions between and among content, pedagogy, and technology (Mishra & Koehler, 2006). This TPCK knowledge is different from the knowledge of a disciplinary or technology expert and not the same as the general pedagogical knowledge shared by teachers across disciplines (Angeli & Valanides, 2009; Mishra & Koehler, 2006; Niess, 2005). TPCK represents a new

direction in understanding the complex interactions among content, pedagogy and technology that can result in successful integration of technology in classroom. Koehler, Mishra and Yahya (2007) stated that TPCK is a situated form of knowledge that is required for the intelligent uses of technology in teaching and learning.

> At the heart of TPCK is the dynamic, transactional relationship between content, pedagogy, and technology. Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate context-specific strategies and representations (Koehler et al., 2007, p. 741).

Good computer skills are not enough for pre-service science teachers to give technology-mediated lessons. Some studies showed that pre-service teachers who had good computing skills with specific training in uses of computers designed better technology-mediated lessons than those who also had good technical skills but no specific training in the educational uses of computers (Angeli & Valanides, 2005; Angeli, 2005; Valanides & Angeli, 2006, 2008). They concluded that teacher educators need to explicitly teach how the unique features can be employed to transform a specific content domain for specific learners, and that teachers need to be explicitly taught about the interactions among technology, content, pedagogy, and learners. Schaverien (2003) used a web-delivered technology and science education context in which pre-service teachers could develop their ability to recognize, describe and theorize learning. This e-learning environment aimed to use advanced technologies for learning, to bring about larger scale improvement in classroom practice than has so far been affected by direct intervention through teacher education. Pre-service teachers' short, intensive engagement with the Generative Virtual Classroom during their practice teaching was examined. Findings affirmed the worth of this e-learning system for teacher education and the power of a biologically based, generative theory to make sense of the learning that occurred.

Angeli and Valanides (2009) proposed five indicators for assessing TPCK in designing instruction with technology: (a) Identification of topics to be taught with technology in ways that signify the added value of tools, such as, topics that students cannot easily comprehend, or topics that teachers face difficulties in teaching effectively in class; (b)

Identification of representations for transforming the content to be taught into forms that are comprehensible to learners and difficult to be supported by traditional means; (c) Identification of teaching strategies, which are difficult or impossible to be implemented with traditional means; (d) Selection of appropriate computer tools and effective pedagogical uses; and (e) Identification of appropriate strategies to be combined with technology in the classroom, which includes any strategy that puts the learner at the center of the learning process. In this study, these five criteria were utilized to assess the development of TPCK for pre-service science teachers. The researchers developed a transformative model of integrating technology and peer coaching to examine the impact on TPCK of pre-service science teachers.

3.1 Peer coaching

Peer coaching provides a community of practice to be defined as a group of individuals, who share such commonalities as interests, knowledge, resources, experiences, perspectives, behaviors, language, and practices (Lave & Wenger, 1991). Bowman and McCormick (2000) suggested that through social interaction, active learning evolves and each participant interprets, transforms, and internalizes new knowledge. Within the framework of peer coaching, such collaborative discussions allow individuals to develop their own perspectives and to model strengths for others. Pierce and Hunsaker (1996) stated that peer coaching not only increases collegiality, but also enhances each teacher's understanding of the concepts and strategies of teaching, and sustains the movement toward restructuring the traditional evaluation efforts by strengthening the ownership of change. Jenkins et al. (2005) suggested peer coaching as a means of developing PCK because of its real-life context in which teaching and learning occur. Peer coaching can increase reflective practice, aid implementation of teaching models and instructional strategies, and enhance classroom management and development of PCK (Jenkins & Veal, 2002; McAllister & Neubert, 1995).

Joyce and Showers (1982) introduced peer coaching as a component of teacher training. A fully elaborated peer coaching model with a planning and implementation focus consists of four elements: (1) the study of the theoretical basis or rationale of the teaching method, (2) the observation of demonstrations by persons who are experts in the teaching method, (3) practice and feedback in relatively protected

conditions, and (4) coaching one another to assist the new method to be incorporated into day-to-day teaching style. In their more recent work, Joyce and Showers (1995) expanded their view of peer coaching, emphasizing learning through collaborative planning, development and observation of instruction. They stressed the importance of a non-hierarchical relationship between peers working and learning collaboratively to improve their teaching.

4 Developing a transformative model

Shulman (1987) proposed that PCK development might pass through the processes of comprehension, transformation, instruction, evaluation, reflection and new comprehension. In this study, peer coaching can be described as a collegial approach to the analysis of teaching aimed at integrating new skills and strategies in classroom practice (Joyce & Showers, 1995). This study revised the instructional model proposed by Joyce & Showers (1995) into the transformative model of TPCK-COPR (TPCK Comprehension, Observation, Practice and Reflection) as shown in Figure 1. This model comprises four main activities: (1) comprehension of TPCK, (2) observation of instruction, (3) practice of TPCK, and (4) reflection of TPCK. The on-line assisted learning of the PCK e-learning system was the platform for implementing the TPCK-COPR model.

First, the peer-coaching model starts at the study of the theoretical basis or rationale of the specific content teaching method. The understanding includes study on the topics of textbook and TPCK articles in teams, and pre-service teacher would describe his/her understanding of the subject-matter knowledge of the specific subject content unit. The analyses and discussions on these PCK and TPCK research articles also contribute to the science teacher's PCK of useful instructional strategies for overcoming secondary students' learning difficulties (Van Driel, De Jong & Verloop, 2002) or identifying some topics difficult to be implemented by traditional means. Second, in order to integrate TPCK theories and practice, the second main activity was to observe experienced mentor teachers. Pre-service teachers should observe the teaching and note their skills according to the learned TPCK theories and strategies. After watching the demonstration, pre-service teachers take turns to give their

comments and suggestions. Third, pre-service teachers learn to design technology-based lesson plans and apply it to teaching practice. After the practices, the peer would analyze and comment on the pros and cons of their teaching. Many related studies indicated that the choice of instructional model related to teaching experience was important for PCK development (De Jong, Van Driel & Verloop, 2005; Gess-Newsome & Lederman, 1993; Loughran, Mulhall & Berry, 2004; Van Driel, De Jong & Verloop, 2002). Finally, each pre-service teacher should show the videotapes of his/her teaching to share his/her teaching experience with others. This teaching practice can stimulate teachers' self-reflection. To reflect is to think about where you have been and/or what has happened in order to clarify your experience (Vidmar, 2006). In this study, the researchers used the transformative model of integrating technology and peer coaching to develop TPCK of pre-service science teachers.

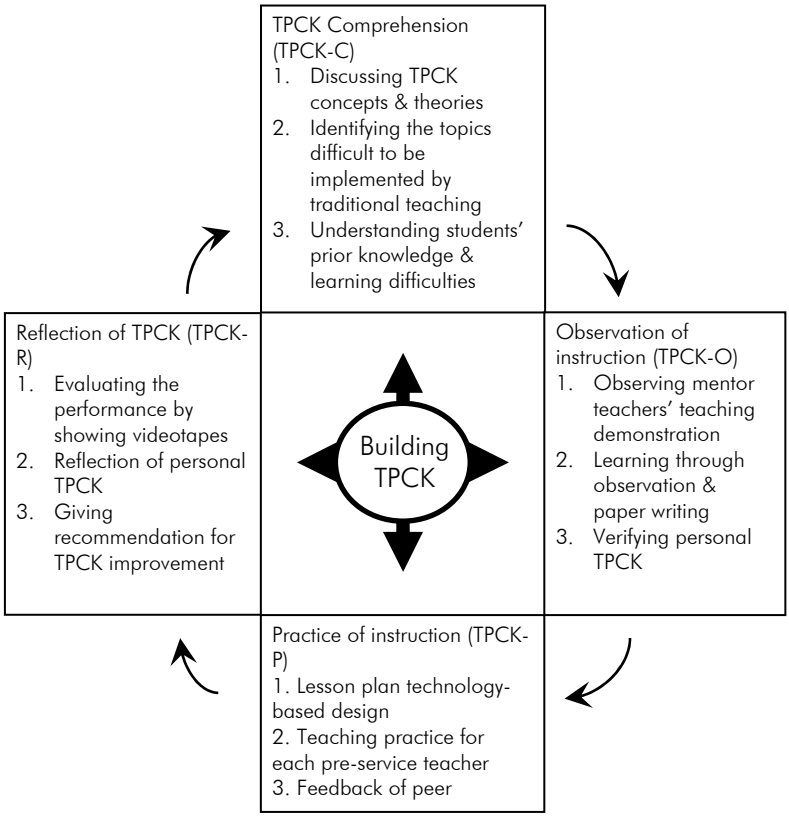


Figure 1. A transformative model of TPCK-COPR

4.1 Research Methodology

Context and Participants

The context of this study was a teacher education course - "Pedagogical Content Knowledge in Science and Technology" designed for pre-service teachers on how to design lesson plan and apply teaching theories and strategies to practice teaching in order to gain teaching experience, pedagogical knowledge, teaching methods and technology. However, the current pre-service teacher programs emphasized teaching theories and methods rather than actual implementation or technology-based application in teaching. In this study, the core course lasted 18 weeks and ran for two hours every week throughout the whole semester. The aims of the course were to combine the science concepts, instructional theories and methods, and technological application to future teaching. The instructor, who was the primary researcher, specialized in science teaching methods, strategies and technology. The participants included a single instructor and a total of 12 pre-service teachers. These pre-service teachers were selected for a two-year teacher education program from the Science College at the University. They were all interested in becoming a science teacher in secondary schools.

Research design

There were 12 participants in this study, which were divided into three groups with four participants in each group. Task I was performed using traditional model and Task II was performed using the transformation model in this study. In the beginning of Task I, the instructor explained the instructional theory, design and strategy. The pre-service teachers then designed the instructional plans with the technology-based teaching strategy individually. Subsequently, they presented their demonstrations one after another. At the same time, other pre-service teachers evaluated their instructional plans and instructional performance according to the criteria of TPCK. Moreover, the instructor conducted expert assessment and the demonstrators conducted self-evaluation. Thus, the evaluation in Task I included self-evaluation (N=12), expert evaluation (N=12) and peer evaluation in each group (N=132).

For Task II, The groups first studied the literature on TPCK and observed the experienced science teachers' demonstrations. Then each

group designed the unit instructional plans by group work and computer-assisted instruction. Each pre-service teacher's instructional plan could be enhanced by peer instruction and review. These teachers also designed the instruction by information technology. After designing the instructional plans, each pre-service teacher presented their demonstrations. Likewise, other pre-service teachers evaluated their instructional plans and instructional performance. The evaluation included self-evaluation (N=12), expert evaluation (N=12) and peer evaluation (N=132).

Traditional model and implementation

During the first six weeks, the learning procedure for this course in the traditional classroom was to have the curriculum content always elaborated by the instructor for the entire semester. The web-based learning technique was not implemented in this stage. The instructor explained the meaning and concepts of instructional principle, design and strategies, such as cognitive teaching and learning and constructivism, using PowerPoint. Sometimes, the instructor would use questioning skills to interact with the pre-service teachers on related questions. The pre-service teachers learned individually how to design lesson plan and apply teaching theories and strategies to practice teaching. They needed to design the lesson plan with technology, and integrate computer activities with appropriate topic-specific pedagogy to teach individually for about 30 minutes. The practice would show the pre-service teacher's application of instructional theories and strategies. After the practice, the instructor and peer would give assessment and instant feedback. The major difference was that the traditional courses did not implement the web-based learning technique, or peer-coaching lesson design and practice.

TPCK transformative model and implementation

The researchers built an on-line assisted learning of the TPCK system to be the platform for implementing the TPCK-COPR model. The online materials for each part of this course contained contents, slides and online references. The setting of the online the teaching system included the curriculum information and resources, forum and online discussion board. Prior to the official implementation of the web-assisted learning

network, pre-service teachers would become familiar with the implementation and functions of the hardware and software and reinforce the support in either hardware or software to prevent possible technical problems. To see how well pre-service teachers learned and retained their attendance online, the instructor would evaluate the pre-service teachers in two ways, individually and within the group, every other week. For individual task, the pre-service teacher had to learn to collect data individually, participate in the discussion and post their comments online to share with other peers at least twice each week. For the group task, team members would post the results regarding the TPCK group homework on the website after they reached consensus through discussions. The four activities of the TPCK-COPR model were integrated into the entire course through four stages as discussed in the following.

Stage One: TPCK Comprehension

From Week 7 to Week 8, this stage included the main activity for understanding the content of TPCK. The instructor, using PowerPoint, explained the meaning and concepts of TPCK including the knowledge of the seven categories, especially students' prerequisite knowledge, creative teaching strategy and application of web-based technology. The instructor might let pre-service teachers study the content of PCK and TPCK in teams. Every pre-service teacher would identify which topics are difficult to be implemented by traditional means and describe his/her understanding of the subject-matter knowledge of the specific subject content unit in his/her journal. After the group discussion and examination, pre-service teachers would note down the knowledge of students' understanding and preconceptions of these topics. Finally, pre-service teachers would post the results of team discussions regarding the TPCK on the website as a routine task.

Stage Two: PCK Observation

In order to integrate TPCK theories and practice, the second main activity (from Week 9 to Week 10) was to have two experienced mentor science teachers demonstrate their teaching of integrating technology with respect to the unit - "Density and Buoyancy". The pre-service teachers should observe the teaching and note their skills according to the learned TPCK theories and strategies. Furthermore, pre-service

teachers not only prepared a written report and posted it on the website, but also discussed the integration of mentor teachers' teaching strategies or methods according to their acquired TPCK.

Stage Three: Lesson plan design and teaching practice

From Week 11 to Week 16, the pre-service teachers learned to design lesson plan and adopt innovative teaching method and strategy in peer coaching practice. The pre-service teachers needed to design the lesson plan with technology collaboratively, and integrate computer activities with appropriate topic-specific pedagogy. Every pre-service teacher of each group could help and learn from each other. However, they would integrate computer activities with appropriate topic-specific pedagogy to teach individually for about 30 minutes. For example, a pre-service teacher used a buoyancy-meter to demonstrate the buoyancy phenomena of water and utilized a computer to assist this demonstration. Pre-service peer teachers would criticize and analyze their observation about the teaching strategies and related teaching activities used by the onstage peer, using the method of writing with the instructional principles and theories they learned from the curriculum in the web-based learning network. The pre-service teachers also needed to have their teaching performance videotaped. At the same time, they would write down their own thinking and raise questions in the online discussion forum. In the end, they had to post their comments online to share with other peers so as to learn from each other.

Stage Four: Reflection and modification

The fourth activity on reflection and modification lasted from Week 17 to Week 18. After completing the teaching practice, pre-service teachers would see the videotapes of their teaching, share with others their teaching experience, and write the reflection in their journals. The purpose of this activity was to evaluate pre-service teacher's teaching performance. Pre-service teachers of each group would take turns to reflect on their own practice; followed by comments from other peers. Finally, the instructor would give appropriate feedback and comment on their demonstration and practice. In this stage, the effects of such integration on TPCK and ability of capitalizing technology among pre-service teachers were evaluated. Furthermore, the reflective stage would

help them self-examine their current lesson plan design and teaching practice in order to modify future teaching practice.

4.2 Assessment procedures and data collection

The assessment of two tasks included self-assessment, peer assessment and expert assessment. According to the five indicators proposed by Angeli and Valanides (2009), the researcher assessed the TPCK of pre-service teachers on designing instruction with technology. The evaluation method and principle were derived from the pre-service teachers' instructional plans and demonstrations. In Task I, members in the same groups discussed each pre-service teacher's instructional plan and demonstration, and indicated their merits and drawbacks. According to the five indicators of TPCK, each pre-service teacher wrote down the peer evaluation and the instructor conducted expert evaluation. Finally, each demonstrator wrote a reflection paper about their individual performance on the first design task and conducted a self-assessment using the five criteria taking into consideration the comments from the instructor and their peers. The evaluation in Task II was made with reference to the transformation model in this study. After computer-assisted instruction and peer coaching, members of other groups discussed the pre-service teachers' instructional plans and demonstrations on information technology and indicated the good points and limitations. Then, evaluations on the pre-service teachers were made according to the five indicators of this study. These teachers wrote down peer evaluation. Likewise, the demonstrators conducted self-evaluation with regard to expert evaluation and peer evaluation as the guideline for the next demonstration. Each indicator were rated using the Likert five-point scale with 5 for 'strongly agree' indicating success in satisfying the criterion., 3 for neutral, and 1 for 'strongly disagree' indicating failure in satisfying the criterion. Thus, total scores for the overall TPCK performance ranged from 5 to 25. A total score of 5 indicated poor TPCK performance and a score of 25 indicated outstanding TPCK performance. The expert assessment of the instructor used the five criteria taking into consideration the Tasks as well as pre-service teachers' self- and peer assessments. A Pearson r between the two ratings was found to be .85. Two different independent raters also performed a qualitative analysis (Patton, 2002) of students' course evaluations that were completed at the end of the semester. The interrater agreement was found to be .91.

The online data included questions and content of the online discussions between the instructor and pre-service teachers, online submission of homework and feedback, communication of personal problems and responses through emails and other related online information. The third source was the reflective journal of pre-service teachers, which served a two-fold purpose. The journal documented the construction, development, and reconstruction of knowledge in relation to density and buoyancy. It also contained each pre-service teacher's personal accounts of successes, failures, misunderstandings and frustrations during the class.

The fourth source was interviews, which served to gain a deeper understanding of the pre-service teachers' conceptions. The first interview was conducted before implementing the model, which was to acquire basic understanding about pre-service teachers' TPCK before the class. It included teaching strategies or representations of technology when pre-service teachers taught these units. The second interview was conducted after implementing the model, which was to explore the extent of transformation of pre-service teachers' TPCK. It included the understanding of learner's knowledge, the changes in teaching knowledge or skills, the abilities of implementing technologies, and the overall changes in TPCK. According to the information gathered from the interviews, the researchers wished to discern the possible discrepancies of their views written down in online articles and journals.

4.3 Data analysis

This research used both quantitative and qualitative approaches. Statistical analysis was performed on the quantitative data from the self-assessment, peer assessment and expert assessment to discover whether the difference in scores of assessment on Task I method and Task II method could reach a significant level. The inductive data analysis employed in this study utilized a qualitative framework that allowed the researcher to build patterns of meaning from the data (McMillan & Schumacher, 2001). Four phases, as described by McMillan and Schumacher, were employed for the analysis of the transcripts: (1) continual discovery throughout the research in order to tentatively identify patterns; (2) categorizing and ordering data; (3) refining patterns through determining the trustworthiness of the data; and (4) synthesizing themes. Accordingly, the researchers assigned the changes

obtained from individual respondents to these categories, resulting in a numerical overview of the results. A constant comparative method was utilized to compare the interview data and other data (online and journals) with the categories generated (Strauss, 1987). The data were first collected, coded, compared and then organized into different categories. Then the data were interpreted according to the categories. In order to quote pre-service teachers' opinions, the researchers used PT1, PT2 …and PT12 to represent the 12 teachers.

5 Results and Discussion

Table 1 shows the descriptive statistics for each criterion used to assess pre-service teachers' TPCK performance on the two design tasks and pre-service teachers' total TPCK competency scores. In order to see if teaching methods were significantly related to the total scores of the two tasks, a one-way ANOVA was employed to compare their scores. The results showed that there were significant differences in "Total TPCK competency "($F = 5.625$, $p < 0.05$). In order to see if each aspect of every criterion was significantly related to the scores of the two tasks, a one-way ANOVA was also employed to compare their scores. As seen in the results, there were significant differences in "Identification of appropriate representations to transform content", "Selection of appropriate computer tools and pedagogical uses" and "Identification of appropriate strategies to be combined with technology" ($F = 5.260$, $p < 0.05$, $F=6.310$, $p < 0.05$, and $F = 10.561$, $p < 0.01$, respectively.), but there were no significant differences in "Identification of teaching strategies difficult to be implemented by traditional means" ($F=0.285$, $P>0.05$), and "Identification of the topics to be taught with technology" ($F=0.310$, $P>0.05$). The researchers classified the results of the study into the following categories.

1. **This model allowed pre-service science teachers to realize that it was difficult to implement traditional instructional strategy on some abstract units; thus, they would tend to incorporate technology in the instruction.**

As seen in Table 1, although the mean score for Task II was higher than that for Task I in the aspect of "Identification of teaching strategies

difficult to be implemented by traditional means", there were no significant differences between these two tasks. In the first interview, pre-service teachers thought that it was not easy to introduce some abstract units (e.g. "electricity", especially the concept of "electric potential") with traditional instructional strategy. There are few models in traditional instruction which can elaborate that high and low electric potential tend to be dependent on currents. It is also abstract to explain the in relation to the concept for "Ampere's right-hand rule". In addition, although some experiments are given when teaching the units of buoyancy and density, the pre-service teachers still think that they are abstract concepts. Three of the pre-service teachers stated:

In my opinion, electricity is abstract and it is difficult to introduce the concept of electric potential using traditional instruction. (PT2 interview)

Although I try to adopt "Ampere's right-hand rule", it is difficult to explain the relationship between electric current and electromagnetic direction to the students. (PT5 interview)

Although there are some experiments given in the units of buoyancy and density, the concept is still abstract. The students can hardly understand the formulas. (PT8 interview)

Table 1. Descriptive statistics of pre-service teachers' TPCK performance

Dimensions of the questions	Task	Mean	SD	N	F
1. Identification of teaching strategies difficult to be implemented by traditional means	Task1 Task2	3.05 3.32	0.96 0.72	156 156	0.285
2. Identification of the topics to be taught with technology	Task1 Task2	3.23 3.55	0.66 0.75	156 156	0.310
3. Identification of appropriate representations to transform content	Task1 Task2	3.25 4.07	0.99 0.77	156 156	5.260*
4. Selection of appropriate computer tools and pedagogical uses	Task1 Task2	3.10 3.91	0.73 0.59	156 156	6.310*

5. Identification of appropriate strategies to be combined with technology	Task1 Task2	3.02 4.15	0.88 0.86	156 156	10.561**
Total TPCK competency	Task1 Task2	15.65 18.18	3.97 3.89	156 156	5.625*

* $P<0.05$ ** $P<0.01$

On the other hand, concerning the aspect of "Identification of the topics to be taught with technology", there were also no significant differences between these two tasks. In the second interview and on-line data, pre-service teachers found that they understood better some topics when integrated into technology-based design through the model. However, some pre-service teachers thought that it was not suitable to integrate technology into the teaching of all science units in a traditional classroom setting. In the process of instruction, if technology can be properly integrated in some units (e.g. electric potential or buoyancy), the animation and course explanation in detail can allow the students to comprehend the meanings. With realistic animation, students would have higher learning interests in understanding the principle of electric potential or degree of buoyancy. Moreover, it is difficult for students to understand "Ampere's right-hand rule" and distinguish the relationship between electric current and electromagnetic direction. With the animation, students can clearly recognize the relationship. Four of the pre-service teachers stated:

> I do not think that every unit in the science course can be taught with integration of technology and it was also difficult to design technology-based lesson in traditional classroom setting. (PT7 reflective journal)

> First, the research papers helped me a lot in understanding students' prior conception of electricity. Then I discussed the concepts through online activities. Finally, I would design Flash activities for the students to check their understanding in teaching practice. (PT1 interview)

> I could design a buoyancy meter to demonstrate the buoyancy phenomenon of water and use a computer to assist in this demonstration. (PT3 interview)
>
> Through the Flash demonstration of peer teaching activities, it is easier for me to understand students' comprehension of the "Ampere's right-hand rule." (PT9 online data)

2. Observing experienced science teachers helped pre-service teachers imitate and apply instructional strategies, films and animations in their teaching

One of the findings in this study was that there was significant difference among pre-service teachers in "Selection of appropriate computer tools and pedagogical uses". The difficulty which pre-service teachers encountered was how to present the science formula and content knowledge to students in an efficient way. The initial process of mentor teaching observation in the study could provide help for an individual who did not have any teaching experience. Pre-service teachers thought that they had learned to design activities with instructional strategies, films and animations after they observed the mentors' teaching. Further, it helped pre-service teachers imitate some practical technological pedagogical strategies and organize their personal thinking. Three of the pre-service teachers stated:

> Observing an experienced teacher can help me design a teaching activity for explaining the abstract buoyancy formula. I use a real-life object, "clay", put in water and let students experience the modified clay shape show its different buoyancy in my teaching practice. (PT4 interview)
>
> I created a multimedia video-recording to illustrate the concept of density and its applications. This idea was inspired by the observation from a mentor teacher's teaching. (PT10 interview)
>
> The observation helped me a lot in developing my instructional strategy. After explaining the important concept of electric current, I will provide some computer stimulation activities for the students to enhance their understanding. (PT5 online data)

"Observation" is a positive model that allows teachers and students to benefit from each other. Each pre-service teacher has his/her own instructional model, and considers it the best. Through observation, pre-service teachers can reflect on their limitations, as suggested in the saying, "seeing another better than oneself, one tries to equal him." With peer observation and demonstration, pre-service teachers can think about improving their future instructions.

3. This model offered pre-service teachers practical opportunities to transform the science content by multiple instructional representations.

Most of the pre-service teachers thought that they were equipped with science content knowledge. However, the science content knowledge seems to be objective to them before the teaching practice experience. In this study, pre-service teachers acquired the opportunities to transform theoretical formula and knowledge into their teaching practices. There existed differences between the students' acquired knowledge and students' problem-solving ability in science courses. Thus, pre-service teachers should teach the science content knowledge by transforming real examples into students' practical experience for a better representation. Two of the pre-service teachers stated:

> Before the course, my knowledge of "density" was objective and formal as the mass per volume for an object. After the teaching practice, I understood the definition of density and how it is calculated, as well as the difference in density between objects. (PT1 reflective journal)

> I found that some students probably understand the concept of buoyancy, but it is still difficult for them to apply it correctly when solving problems. They did not know how to use a formula to solve problems. In my opinion, there is significant difference between students' acquired knowledge in science course and their problem-solving capability. (PT12 interview)

As seen in Table 1, there was significant difference among pre-service teachers in "Identification of appropriate representations to transform

content". The results showed that pre-service teachers in Task II have learned how to develop skills in integrating technology to design more interesting and lively teaching content and activities in their teaching practice. The model offered pre-service teachers a teaching practice opportunity to transform their TPCK. It was possible for pre-service teachers to connect their professional knowledge of the subject matter with their teaching methods. Pre-service teachers learned how to use computer-assisted teaching method to interpret the teaching units in a more comprehensive way than the traditional teaching method. Two of the pre-service teachers stated:

> The model had given me lots of practical experience and helped me transform content knowledge and teaching skills in a classroom practice. It helped me clarify areas of strength and weakness of my teaching. (PT6 interview)

> The model helped me use computer-assisted teaching method to interpret the subject matter in the unit of density in a more comprehensible way. (PT3 reflective journal)

4. Pre-service teachers reflected that they had learned TPCK and how to integrate technologies with teaching

There was significant difference among pre-service teachers in "Identification of appropriate strategies to be combined with technology". These pre-service teachers reflected that they had learned how to integrate technologies with teaching through the transformative model and the web-based learning environment and related websites. They would connect the television in the classrooms with their notebook computers and support their instruction by online resources; they could describe some abstract units (e.g. electric potential and buoyancy) by visual interactive model and animation. In this study, through peer coaching and online discussion, pre-service teachers could exchange their ideas and opinions when they had questions about the course. This provided them with an avenue to obtain instant feedback and learn related pedagogical content knowledge with technology. Three of the pre-service teachers stated:

> When I explain "Ampere's right-hand rule", I try to make students understand the relationship between electric current and electromagnetic direction by the animation of the experiment upon the principle. Finally, I will enhance the students' memory by my right-hand explanation. (PT7 interview)

> I would like to use TV programs from the Discovery channel and Internet resources in my teaching with respect to electricity. (PT8 online data)

> To illustrate buoyancy of liquid, I present the concept using the Flash program, which has an immediate effect on students' comprehension. What a magic effect of the application of Flash! Students learned by observing the phenomena of buoyancy from the presentation. (PT2 interview)

6 Implications and Conclusion

According to the results, there were significant differences in the aspect of "Total TPCK competency." This study provided empirical evidences showing that the transformative model did have some impact on pre-service teachers' TPCK in particular topics of subject matter. However, there have been few studies on TPCK and the relation between technology-based model and PCK of pre-service teachers (Angeli & Valanides, 2009; Koehler, Mishra & Yahya, 2007; Niess, 2005). According to the transformative model, this study expanded four views namely, the comprehensive, imitative, transformative and integrative views to explore the development of TPCK. From the comprehensive view, the model helped pre-service teachers understand better their TPCK. Pre-service science teachers understood clearly that it was difficult to implement traditional instructional strategy on some abstract units (e.g. electric potential, current, buoyancy or density); thus, they would tend to incorporate technology in the instruction. In this study, analyses and discussions on these PCK research articles also contributed to the pre-service teachers' PCK of useful instructional strategies for overcoming secondary students' learning difficulties (Van Driel, De Jong & Verloop, 2002). In general, reading and discussing the paper had triggered the development of pedagogical knowledge for at least some of the

participating pre-service teachers. By getting acquainted with students' specific conceptions and online ways of learning, pre-service teachers might use some technology-based examples to motivate students for learning. If technology could be properly integrated in some units (e.g. electric potential or buoyancy), the animation and course explanation in detail could allow students to comprehend the meanings. This would restructure their abstract subject-matter knowledge into an easy understandable form that enables productive communication with their students (Lederman, Gess-Newsome & Latz, 1994).

According to the imitative view, pre-service teachers have learned to imitate and develop TPCK by observing mentor teachers. Pre-service teachers can learn how to apply technology by observing mentor's usage of technology. This way of learning new experience by observing others is called "vicarious learning" (Bandura, 1986). It is suitable for pre-service teachers with no real teaching experience to learn new technology. In this study, specifically, observing an experienced mentor teacher can help pre-service teachers design a teaching activity for explaining the abstract buoyancy formula. They have learned how to use instructional strategies, internet resources, films and animations in the instruction. Learning technology by the design approach is a constructivist approach that sees knowing as being situated in action and co-determined by the peer interaction environment (Brown, Collins & Duguid, 1989; Koehler, Mishra & Yahya, 2007; Young, 1993). Furthermore, pre-service teachers in teaching practice utilized some practical TPCK in the classroom while the traditional teacher education class focused on self-construction of knowledge.

According to the transformative view (Angeli & Valanides, 2009; Gess-Newsome, 1999), TPCK is considered as a distinct set of knowledge constructed from other forms of teacher knowledge. Pre-service teachers' knowledge of representations and teaching strategies had benefited and developed in the actual teaching experience. This strong impact of teaching experiences is consistent with the findings of other scholars (De Jong, Van Driel & Verloop, 2005; Grossman, 1990; Lederman, Gess-Newsome & Latz, 1994). Pre-service teachers developed their TPCK, which has been described as the transformation of several types of knowledge for teaching (Magnusson, Krajcik & Borko, 1999). Since the science formula and theories learned by the traditional teaching method were usually considered objective and abstract, pre-

service teachers found it easier for them to combine the theory with practice and further organize their subject-matter knowledge through the innovative teaching model. It was possible for pre-service teachers to connect their professional subject-matter knowledge with their teaching methods (Lederman, Gess-Newsome & Latz, 1994). According to Geddis (1993), the transformation turned pre-service science teachers' subject-matter knowledge into teachable content knowledge. Pre-service teachers might use computer-assisted teaching method to explain the important concepts by designing some exercises for students to experiment with the concepts they acquired.

According to the integrative view, TPCK is not considered a distinct form of knowledge, but a body of knowledge, which is made up of other forms of teacher knowledge that are integrated during the act of teaching (Angeli & Valanides, 2009). The instruction model helped pre-service teachers integrate appropriate strategy and technological application efficiently in their teaching practice. In this study, using methods of online discussion, pre-service teachers could exchange their ideas and opinions. This provided them with an avenue to obtain instant feedback and learn related technology knowledge. It increased the opportunities for communication, explanation and exchange of their experiences with peers (Dalgarno & Colgan, 2007). In other similar studies, the researchers learned that pre-service teachers could enhance the application of technology and knowledge by integrating technology into teacher education courses (Angeli, 2005; Jang, 2008a).

In conclusion, the model succeeded in contributing to the development of TPCK of the participating pre-service teachers. That is, it turned out to be useful to start the model with activities focusing on explicating pre-service teachers' initial knowledge of some abstract units difficult to be implemented by traditional instructional strategy, and expanding these notions by analyzing and discussing fragments from TPCK comprehension activities. The activity also appeared to stimulate their thinking about potentially useful instructional technological strategies. Next, the initial process of teaching observation in the study could provide help for an individual who did not have any teaching experience. It helped pre-service teachers imitate some practical TPCK, and organize their personal thinking to verify the theories in textbooks. The mentors' approach and involvement indicated their potentially strong impact on the development of pre-service teachers' TPCK. Then,

it was important that pre-service teachers were provided with authentic opportunities to experiment with teaching approaches. In this context, some of them appeared to have focused on the design of their instructional approach, whereas others had concentrated on how to transform technologies with teaching through the web-based learning environment. Finally, writing a reflective lesson report and discussing their videotaped performance with each other turned out to be useful in helping pre-service teachers explicate, and further integrate their TPCK about students' learning difficulties, instructional strategies and technology. Therefore, not only was the integration of technology and an innovative model a way to develop science pre-service teachers' TPCK, it was also a good teaching strategy for promoting the utilization of instructional technology in teaching for pre-service teachers.

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INNOVATIVE INSTRUCTIONAL INTERVENTION AND THE NEED FOR A BETTER INSIGHT INTO INSTRUCTIONAL CONCEPTIONS

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SUMMARY

Designed innovative instructional interventions based on modern learning theories and advanced learning technologies are advocated for the acquisition of quality knowledge. However, it is believed that learners interact with innovative instructional interventions in accordance with their instructional conceptions rather than the intentions of the designer/teacher of the innovative instructional interventions. Instructional conceptions moderate the effect of innovative instructional interventions for the acquisition of quality knowledge (Lowyck, Elen, & Clarebout, 2004). Learners' instructional conceptions refer to students' ideas about how (innovative) instructional interventions relate to their learning (Elen & Lowyck, 1999). The relevant literature indicates that students have instructional conceptions about learning environment in general and about specific interventions in particular. This indicates that designing an innovative instructional intervention for the acquisition of an integrated set of knowledge and skills requires better understanding of students' instructional conceptions. However, due to measurement issues and terminological confusions, a broadly accepted measurement instrument is not yet available in the literature.

This contribution discusses the development of a survey containing items assessing students' general conceptions as well as items measuring students' specific instructional conceptions about particular innovative instructional intervention. To test the reliability of the items, 3 validation studies were done, with respectively 310, 108, 85 students in three countries. Results indicate that

the instrument is not sufficiently reliable for assessing general instructional conceptions but is highly reliable for measuring specific instructional conceptions. The results of the study suggest that for specific instructional conceptions this instrument can be used by teachers and instructional designers to investigate students' instructional conceptions of the innovative instructional intervention and - if needed - adjust it.

KEY WORDS: Quality knowledge, Modern learning theories, Advanced learning technologies, Instructional conceptions, Innovative instructional interventions

1 Introduction

Quite a lot of socio-economic and technological developments have remarkably changed our ways of thinking about learning and designing of instruction. In the 21st century, pedagogical innovative interventions rooted in cognitive and social constructivist learning principles have been acknowledged for supporting the acquisition of productive knowledge (Decorte et al., in press;; Collins et al., 1989). Innovative instructional interventions based on these principles are intended to facilitate students' learning. It has been argued that the use of information and communication technology (ICT) may be an additional help to support learning (Lehtinen, 2003). Even though a group of researchers (e.g., Clark 2001; Russell, 1999: Sarfo & Elen, 2007) argued that innovative use of ICT cannot bring significant difference in learning gains, advocates in ICT in teaching and learning (e.g., Kozma, 1991, 1994) stress that the use of ICT may help to deliver innovative and powerful interventions.

With or without ICT, an important principle of innovative instructional interventions relates to task centered learning (Merrill, 2006). Task centered learning starts from the assumption that learners actively construct learning experiences based on their own experiences and conceptions. This has important implications as innovative instructional interventions are not in themselves powerful. Their effectiveness is

moderated by what students do with the interventions. These actions are affected by learners' conceptions. To put it bluntly, rather than the intentions of innovative instructional designers or teachers, it is learners' conceptions about interventions that determine how learners interact with the innovative instructional intervention and hence what it's effect can be (Konings et al. 2005; Lowyck et al. 2004)

The construct 'instructional conceptions' refers to all ideas, concepts, and theories that an individual learner holds about (components of) learning environments. Instructional conceptions as defined by Lowyck et al. (2004) are not conceptions about scientific phenomena to be influenced by instruction. Neither are instructional conceptions identical to conceptions of learning (e.g., Saljö, 1979; Kemba, 2001) as they directly focus on students' conceptions hold about instructional interventions themselves (Lowyck et al. 2004; Sarfo & Elen, 2007). The notion of instructional conceptions clearly differs from the notion of learning conceptions. While instructional conceptions refer to students' ideas about the relationship between instructional interventions and learning in general, learning conceptions refer to students' ideas on how they learn themselves. The literature on instructional conceptions (e.g., Clarke, 1994; Cooper & McIntyre, 1994; Elen & Lowyck, 2000; Elen & Lowyck, 1999; Hativa & Birenbaum, 2000; Kember, 2001; Salomon, 1984) reveals that students have instructional conceptions about 1) instruction or learning environments in general, and 2) specific components of learning environments, such as innovative instructional interventions or instructional media. Instructional conceptions can therefore be classified into general and specific ones. For instance, in order to measure students' preferred teaching approaches and academic discipline, Haitiva and Birenbaum (2000) used 174 undergraduate university students as subjects. Their questionnaire consisted of 'approaches to teaching: The results indicated that students' most favored teaching approach is the lecturer who is organised, clear and interesting. Least favored are information transmission and promotion of self-regulation. Similarly, Marek et al. (1999) study revealed that students are less inclined to use adjunct aids since this requires a more elaborative study pattern. Furthermore, based on a qualitative study, Elen and Lowyck (2000) concluded that university students (N = 244) hold specific ideas about learning in an instructional settings as well as a precise delivery system (e.g., computer) and self study package.

Research evidence (Elen, 1995; Entwistle, 1991; Entwistle & Tait, 1990; Shuell, 1988; Winne, 1987; Winne & Marx, 1982; Willems, 1987) seems to show that learners' conceptions act as a variable that moderates the impact of learning environments. Lowyck et al.(2004) suggest that specific innovative teaching and classroom behaviours determine learning results through the filter of students behaviours and cognitions, and hence, these behaviours and cognitions influence the effectiveness of innovative instructional interventions. Instructional conceptions affect how the learning environment will be perceived and acted upon (Lowyck, Elen & Clarebout, 2004). This goes back to Rothkopf (1968, 1970) who indicated that students do not react to the objective or nominal instructional stimuli as constructed by the innovative designer or teacher but to the stimuli as transformed by the students themselves. Similarly, Winne (1985) indicates that students use instructional interventions according to the functions they attribute to these interventions. Students' attributed functions are based on their instructional conceptions (Lowyck et al. 2004). In addition, Konings et al. (2005) and Goodyear (2000) assert that designers or teachers do not directly influence students' learning.

These theoretical claims assume that students do have instructional conceptions which affect students' interpretation of instructional interventions and therefore moderate their effectiveness (Elen & Lowyck, 1999). Taking this assumption for granted, it is indicated that instructional conceptions get considered when designing, developing, and implementing innovative instructional interventions. This, in turn, presupposes that instructional conceptions are well-understood and that design decisions can be based on sufficient scientific evidence. Winne and Marx (1982) conclude that innovative instructional interventions are seemed effective only if learners are calibrated to the intentions of instructional designer or a teacher, and make use of these innovative interventions. In order to avoid a possible lack of calibration, Lowyck and (Elen 1994) argued in favor of more explicitly assessing and considering students' ideas about instructional interventions. However, empirical evidence in the literature on instructional conceptions shows that there is no reliable and valid instrument to assess students' instructional conceptions. More specifically, in order to be able to compensate for the moderating role of instructional conceptions that do not comply with the instruction or a specific innovative instructional

intervention at hand, a research instrument is needed that cannot only be used by researchers, but also by innovative teachers. This may reduce the probability that because of certain instructional conceptions the effect of innovative instructional interventions may be hampered. Moreover, a reliable and valid instrument will allow researchers to gain more and better insight about the role of these instructional conceptions, and hence will give them an opportunity to consider these conceptions when conducting research on the design of learning environments. To develop such an instrument, first some methodological issues in research on instructional conceptions will be addressed. Next, a research instrument is proposed and tested. In the discussion and conclusion, the instrument is critically reflected upon.

2 Research on Instructional Conceptions: Methodological Issues

Research on instructional conceptions is directed by the following research issues (Elen & Lowyck, 1999; Lowyck et al., 2004): (1) investigation of interrelationships between instructional conceptions and other types of knowledge; (2) study of the relationships among instructional conceptions, study strategies, and learning outcomes; (3) studies describing the development of instructional conceptions, and (4) intervention studies to alter students' instructional conceptions.

However, the impact of this research is limited because a broadly accepted and reliable instrument to 'measure' instructional conceptions is still lacking in the literature on instructional conceptions. A critical study of the literature indicates that a diverse set of approaches and instruments are used. Clarke (1994), for instance, used an open-ended questionnaire to measure instructional conceptions in relation to learning environment. He gave students a description of 6 learning environments (e.g., large group lectures with more than 50 students). Students had to indicate what they (dis)liked and what they thought would help or hinder learning. The results indicated that students like clearly structured practical applications, well-structured materials, interventions that increase interest and promote informal learning, as well as interventions that promote consolidation and integration of knowledge. Hativa and Birenbaum (2000) used questionnaires that

consisted of 4 approaches of teaching to measure students' preferred teaching approach and related them to students' learning approaches and academic disciplines. Results indicated that well-organized, clear and interesting lectures are students' most favored teaching approach. They least favored information transmission and self-regulation. Furthermore, to measure students' conceptions about learning and knowledge, Kember (2001) conducted semi-structured face-to-face interviews. The results revealed that novice students view instruction as a didactic process of transmitting knowledge while experienced students view teaching as a process of facilitating learning. In a few other cases (e.g., Cooper & McIntyre, 1994) interviews together with observations were used to assess students' instructional conceptions.

The above studies show that not only different measurement instruments are used, but that also a diverse set of terms refers to instructional conceptions. Clarke (1994) for instance, talks about likes and dislikes in learning for specific learning environments, whereas Hativa and Birenbaum (2000) refer to students' preferences for different teaching approaches.

These studies reveal terminological confusion and methodological diversity in instructional conception research. Instructional conceptions are captured through a diverse set of instruments and often in an indirect manner, namely through what students like or dislike themselves. Although the different instruments may be psychometrically sound in the context of the paper, each of them has a number of potential limitations in the context of the construct "instructional conceptions". For instance, well-focused in-depth interviews may be better suited to understand students' instructional conceptions. However, students seem to lack well-elaborated vocabulary on instructional issues (Clarebout, Léonard, Lowyck & Elen, 2003; Elen & Lowyck, 1999), and, hence, they normally do not seem to be able to exactly and fluently express their knowledge about instructional features. With respect to questionnaires, research has revealed a tendency of students to agree with all different statements resulting in not sufficiently differentiating information (Elen & Lowyck, 1999). Clarke (1994) advocated in favor of a semi-structured but open-ended format. However, gathering semi-structured but open-ended data is a difficult endeavor and expensive to conduct (from the perspective of teachers) especially when the sample size is large (Rossi & Freeman,

1993). Importantly, a closer inspection of studies to measure general instructional conceptions, (e.g., Clarke, 1994; Kember, 2001), indicates that the instruments used lack a clear theoretical framework. They do not, for instance, clearly specify and operationally defined the various components of general instructional conceptions (see for instance, Denessen, 2000): goals of education, relation between teacher and student, content of education and educational approach. Most instruments only focus on one particular aspect. In addition the research instruments sometimes do not consider potential differences between general and specific instructional conceptions.

Given the educational importance in relation to designing pedagogical innovative intervention and potential of the instructional conceptions construct, the absence of a broadly accepted and reliable instrument is hampering the progress of this line of research. In this contribution, a proposal is made for a survey-instrument in order to allow for large-scale measurements of general and specific instructional conceptions. Results from the pre-testing phase and of three studies in three different countries (South Africa, Belgium and Ghana) are discussed.

3 Instrument Construction

The construction of the instrument builds on the definition of instructional conceptions provided by Lowyck et al. (2004, pp. 433): "Students' ideas about relationship between the learning environment on the one hand and their learning (processes and outcome) on the other". The selection and formulation of the specific items was then based on experiences with earlier attempts. Previously used questionnaires (e.g., Clarebout, Elen & Goolaerts, 2003; Clarebout, Elen, Luyten & Bamps, 2000; Elen, Clarebout, Luyten & Bamps, 1999) basically revealed that students' general conceptions deal with three aspects of the learning environment, namely goals of education, the role of the student, and the role of the teacher. In line with Denessen (2000) educational goals can be classified in three types: 1) goals that relate to the preparation for work; 2) goals that relate to the personal development or enrichment, and 3) goals that relate to promoting social integration and 'good' citizenship'. For the roles of the teacher and student, four aspects are dealt with, namely who determines 1) learning

goals, 2) learning content, 3) learning support, and 4) assessment (Table 1). These four components are retrieved from a formal description of learning environments by Elen (2003) and are in line with the CLIA[8]-model for designing powerful learning environments as described by De Corte, Verschaffel and Masui, (2004). For each of the types of goals there were specific items, and for each of the potential categories of roles of 'learners' and 'instructional agents' items were constructed. These aspects (goals and role of teacher/student) are addressed in the first part of the questionnaire.

Table 1. Items measuring general instructional conceptions

Goals of education
Prepare for work
Education should help students to get a job.
Education should help students to earn money.
Education should help students to acquire specific job related skills.
Personal development
Education should help students to become knowledgeable.
Education should help students to think critically.
Education should help students to learn how to study.
Social integration
Education should help students to become a full member of society.
Education should help students to get acquainted with norms and values of society.
Education should help students to become responsible adults.
Role of teacher and student
Learning goals determination
Students learn best if they can participate in deciding what has to be learned.
Students learn best if they can set their own learning goals.
Students learn best if it is clear what is expected of them.
Students learn best if the learning objective is provided.

[8] CLIA stands for Competence Learning Intervention Assessment

Table 1. (continued)

Learning content
Students learn best if they can decide what information to study.
Students learn best if they can decide what problems to solve.
Students learn best if all information is provided to them.
Students learn best if all problems are presented to them.
Learning support
Students learn best if they can decide themselves how to study.
Students learn best if they can do it their own way.
Students learn best if they are heavily supported.
Students learn best if they are told how to study.
Assessment
Students learn best if they can assess themselves what they have learned.
Students learn best if they can determine for themselves how well they learned.
Students learn best if the teacher evaluates what they have learned.
Students learn best if the teacher determines how well they learned.

In the second part of the instrument, specific instructional conceptions are addressed by questioning the functionalities of components of learning environments. These conceived functionalities are investigated since Winne (1985) specifies that the use of specific pedagogical innovative interventions depends on the functionalities ascribed to the intervention by the student. This second part addresses the contribution of an innovative learning environment's components, for instance, medium, method, or strategy to learning in a specific context. Indeed, it is assumed that conceptions may be context-specific. It might be, for example, that for technical education lectures are not conceived to be functional while for university education they are conceived to be highly functional (e.g., Elen, Lowyck & Bamps, 1998). The conceived functionality in this instrument pertains to the extent of facilitation of the learning process, motivational aspects, and to the innovativeness (effectiveness and efficiency) of the instructional intervention. Before presenting the questions to the subjects, the specific context is specified, for example: "Please answer the following questions for the following situation: technical education". Table 2 presents the 8 items that were constructed to measure the conceived functionality of a learning environment's specific component.

Table 2. Items measuring specific instructional conceptions

Specific component encourages students to start working.
Specific component helps students to better understand the content.
Specific component helps students to determine what and how to study.
Specific component allows students to do exercises.
Specific component directs students' attention to relevant aspects.
Specific component helps students to think critically about their own study activities
Specific component makes students' learning faster.
Specific component makes students' learning easier.

The following decisions were taken to formulate the items and the answering scale. In order to avoid confusion between instructional and learning conceptions and in order to ensure that respondents would express their 'theoretical' ideas about instruction, each question starts with 'According to me…' instead of 'For me…'. Similarly, it was decided to use 'students' instead of 'I' to make it more general.

With respect to the scale, a 6 point-Likert-type scale was constructed from 'I totally disagree' to 'I totally agree'. No midpoint alternative was included. Midpoint alternatives assume that respondents will have no opinion about a certain statement. Research on the use of midpoints (Billiet, Loosveldt & Waterplas, 1984; Krosnick, & Abelson, 1997) indicates that only seldom people spontaneously offer midpoint responses, but they do frequently select them when offered in a scale. Weems and Onwuegbuzie (2001) also indicate that a midpoint alternative is overselected when offered and that this might influence the internal consistency of a research instrument.

For the number of scale points, the optimal scale length suggested by Krosnick and Abelson (1997) was considered. They indicate that this might be expected to fall between 4 and 7. It allows respondents to differentiate in their opinions and to still have interpretable scale points. Research on scale reliability with different scale points (see Krosnick & Abelson, 1997 for a review) indicates that scales with 5 to 8 scale points are more reliable than scales with either less or more scale points. Using a relatively large number of points on this ordinal scale allows treating these data as interval data (de Heus, Van der Leeden & Gazendam, 1996, Pedhazur & Pedhazur-Schmelkin, 1991), consequently allowing

parametrical data analysis. The use of a Likert-type scale implies that subjects can agree/disagree with all statements, they do not have to make a choice between two or more statements. This follows research findings (Clarebout et al., 2003, Léonard, Clarebout, Lowyck & Elen, 2003; Rinn, 2003; Vermunt & Verloop, 1999) that these conceptions do not relate to one dimension (e.g., teacher- versus student-oriented). In other words, a high score on a teacher-oriented question does not exclude a high score on a student-oriented question. Even if this assumption was wrong, this type of scale allows detecting it.

All items in part 1 were randomized to construct the final questionnaire.

4 Pilot test

Participants

Ten technical secondary education students (17 years old) in Ghana and 205 college students in Belgium participated. The 205 Belgian students consisted of 84 first year teacher education students and 121 third year industrial engineering students.

Procedure

With 10 Ghanaian students cognitive interviews were administered. These interviews allow us to gain insight into the meaning attributed to each item by the students (Billiet, 1997; Desimone & Le Floch, 2004). For each item, students were asked what their answer would be, why and what they actually understood for each question. For the items related to specific instructional conceptions, the context was specified towards technical education and the specific innovative methods were games, integrated project activities, computers, examples and lectures. Based on the results of this pre-test, the questionnaire was adapted to be administered with the 205 Belgian students. The Belgian students received a Dutch translation of the questionnaire with questions about the functionalities of pre-questions, a calculator, examples, graphics and drawing programs in higher education. The questionnaire was administered during a regular lesson.

Results

The cognitive interviews revealed that most questions were understood as intended. Two problems occurred in the first part (general instructional conceptions), namely with the items relating to evaluation. The item 'students learn best if they can determine themselves how well they learned' and the item 'students learn best if the teacher determines how they learned' created confusion. These items were interpreted identically as the items 'students learn best if the teacher evaluates what they have learned' and 'students learn best if they can assess themselves what they have learned'. Students did not make a distinction between evaluating what they learned and how well they learned. In the final version of the questionnaire, the two latter items were kept and the other two were removed.

With respect to the remaining items no problems were detected. In their answers, students also explained the questions by referring to 'students' rather than to their own person. Hence, the assumption that their answers reflect their instructional conceptions rather than their own learning conceptions seems validated.

The Belgian college education students received the questionnaire without the 2 evaluation items. Due to the limited number of subjects no factor analysis was performed on the 23 general items, but the correlation matrix was studied thoroughly to identify problematic items. Since all items correlated significantly ($p \leq .05$) with more than one other item, all 23 items were included in the final instrument. For the part on specific instructional conceptions, factor analyses were performed since there were only 8 items and 205 subjects. These factor analyses resulted in a one or 2 factor solution for the different components or interventions. In view of a parsimonious solution, the Cronbach's alpha for the 1 factor solution was checked, including all 8 items in one scale. This resulted in alphas between .73 and .88. Given these alphas, it was concluded that the scale consisting of the 8 items is reliable, and measuring one underlying latent variable, namely conceived functionality.

5 Validation Studies

Considering the outcomes of these pre-testing initiatives, the questionnaire was used in three different settings: South-Africa, Belgium and Ghana. Participants were university, college education, and secondary technical education students. The South-Africa study is the study with the largest group of participants. This study is considered to be the reference study. The Belgium and Ghana studies look for confirmation and investigate whether the scales found in the South-Africa study can be retrieved with sufficiently high internal consistencies as an indicator of reliability.

5.1 South-Africa study

Participants

Participants were 310 undergraduate students from the Department of Education of a public South-African University. The administration of the questionnaire was part of a broader study.

Procedure

The questionnaire was administered during the first session of a two session-study on the effect of adjunct aids on learning outcomes (Elen & Louw, 2006). All students participated voluntarily and selected a slot that suited them best. Students could work at their own pace. All students finished filling out the questionnaire within 20 minutes.

After data input, the SPSS-program was used to analyze the data. Separate analyses were done for the first (general instructional conceptions) and the second part (specific instructional conceptions) of the questionnaire. In order to determine the number of factors a principal components analysis was executed for the first part. Based on an inspection of the eigenvalues and screen-plot, a two-factor solution seemed most indicated. Next, a maximum likelihood analysis with varimax rotation was performed with the specification that two factors should be extracted. This two-factor solution explained 29.69% of the variance. Seven items with loadings lower than .40 on any of the factors were excluded from further analysis. For the second part a similar approach was followed. A solution with one factor for each specific intervention (examples, questions, and figures) seemed most indicated.

No items had to be excluded. After factor analyses, scales were constructed and Cronbach alphas were calculated in order to assess internal consistencies.

Results

Based on the analyses, two scales with reliability of respectively .85 and .75 could be constructed for the first part of the questionnaire dealing with general instructional conceptions. Table 3 presents the two scales. These scales were labeled 'goal-oriented teacher regulation' and 'student regulation'. Students scoring high on the goal-oriented teacher regulation scale believe that education should prepare them for becoming a full member of society who has the necessary skills to get a job and that students learn best when everything is clearly specified. Students scoring high on the student activity scale believe that students learn best if they can themselves decide on a number of things, such as what problems to solve, what has to be learned, what information has to be studied.

For the second part on conceived functionality or specific instructional conceptions, three scales were constructed. Each scale relates to the conceived functionality of one particular adjunct aid. The scales can be considered to be internally consistent given the high Cronbach alphas (examples: .88; questions: .92; figures: .92; see also Table 4).

5.2 Belgium study

Participants

Participants were 108 first year university students from Psychology and Educational Sciences and Social Sciences. The administration of the questionnaire was part of a broader research study.

Procedure

Within the framework of the broader study, the questionnaire was administered together with other instruments, during a specifically reserved timeslot. Students received four instruments and could take one hour to complete all instruments. The specific instructional conceptions part of this questionnaire consisted of questions relating to problem solving activities and specific instructional tools (calculator, information list, etc.) given the interest of the main study.

For the analysis, it was checked whether the scales constructed in the South-Africa study gave sufficiently high internal consistency values.

Result

The Cronbach alphas for the different general instructional conceptions-scales did not reveal high internal consistencies (Table 3). For the goal-oriented teacher regulation-scale a Cronbach alpha of .62 was found. The 'if-item deleted' statistics revealed that the internal consistency of this scale could be increased to .63 when deleting item 5. For the second scale, the student regulation-scale, an internal consistency value of .61 was retrieved. The if-item-deleted statistics revealed that internal consistency could be increased when item 16 would be left out to .71.

For the specific instructional conceptions on the other hand, reliabilities between .72 and .93 (Table 4) were found, indicating that for this part of the questionnaire, good internal consistencies were confirmed.

5.3 Ghana study

Participants

Eighty-eight students from three second year secondary (technical) schools in Ghana participated in the study. The average age of the participants was 17 years.

Procedure

The administration of the instructional conception questions (both general and specific) took place on the first day of a three-day study. The specific instructional conceptions part of the questionnaire included students' conceptions about functionalities of lectures, integrated project activities, examples, computers, and gaming.
Questionnaires were administered to the students in the three schools during regular classroom sessions. Students could work at their own pace. They all finished answering the questions within 40 minutes.

Results

With respect to the general instructional conception scales, the Cronbach's alpha was .59 and .48 for respectively the goal-oriented teacher regulation and the student regulation scale (Table 3). Deleting an item did not increase the reliability for these scales.
For the specific instructional conception scales, Cronbach's alpha were higher (see Table 4), namely between .62 and .87.

Table 3. Scales retrieved through factor analysis

	Cronbach alpha		
Scale 1: Goal-oriented teacher regulation scale *(item nr)*	*South-Africa*	*Belgium*	*Ghana*
	.85	.62	.59
One of the main goals of education is to help students to become a full member of the society. (2)			
One of the main goals of education is help students to know a lot.(3)			
One of the main goals of education is to prepare students for getting a job. (5)			
Students learn best if the teacher evaluates what they have learned. (7)			
Students learn best if they get help from their teachers and other students. (8)			
One of the main goals of education is to help students to become responsible adults. (9)			
One of the main goals of education is to help students to acquire specific job related skills. (11)			
One of the main goals of education is to help students to get acquainted with norms and values of the society. (17)			
One of the main goals of education is to prepare students for lifelong learning. (18)			
Students learn best if the learning objective is provided. (19)			
One of the main goals of education is to help students to think critically. (20)			
Students learn best if it is clear what is expected of them. (23)			
Scale 2: Student regulation scale (item nr)	.75	.61	.48
Students learn best if they can decide what problems to solve. (10)			
Students learn best if they can participate in deciding what has to be learned. (13)			
Students learn best if they can decide what information to study. (14)			
Students learn best if they can assess themselves what they have learned. (16)			

Table 4. Internal consistencies for the conceived functionalities-part

	Cronbach Alpha		
Tool	South Africa	Belgium	Ghana
Figure	.92		
Example	.88		.71
Questions	.92		
Calculator		.75	
Information list		.72	
Excel sheet		.76	
Route planner		.93	
Problem solving script		.77	
Concept map		.81	
Drawing program		.91	
Reporting script		.86	
Technical help		.86	
Note taking tool		.76	
Lecture			.74
Computer			.62
Integrated project activities			.68
Gaming			.87

6 Discussion and Conclusion

In this contribution an attempt was made to construct a reliable instrument to enable educational practitioners to get a better insight about students' general and specific instructional conceptions towards the design of pedagogical innovative interventions for acquisition of quality knowledge in modern education. This instrument tries to assess students' instructional conceptions in a direct way, instead of retrieving them through students' preferences or perceptions. Although open questions and interviews might be suitable to gain insight in these conceptions, they do not allow for large-scale research given the time consuming analyses.

The results in the different studies do not completely corroborate one another. With respect to general instructional conceptions, different results are obtained. The following reasons may explain the deviation from the South-African study.

A first reason could be the use of a Dutch translation of the questionnaire in the Belgian study. Although a conceptual translation (see McKay et al., 1996) was made, it could be that the same items were interpreted differently in Dutch than in English. It must be noted, however, that also in the Ghanian study no high reliabilities were found, while here the same language was used as in the South-African study and while also the cognitive interviews were performed with Ghanian students. It could be argued that although the language used for instructions in both African countries is the same, item interpretation might be different. Cognitive interviews with students in the three countries could give more insight into this issue.

Secondly, the administration of the questionnaire was part of a broader study in all three studies. However, the other administrated instruments were not the same in these studies. Some influence of the other instruments might have caused 'noise' in the data.

Furthermore, it should be noted that from the 23 initial general instructional conceptions items, 14 remained after factor analysis. It seems that even though in the South-African study high internal consistency measures were found for the general instructional conceptions, still 9 items had to be dropped for further analyses. Taken this finding together with the low reliabilities found in the Belgian and Ghanaian studies, some questions can be raised towards the usefulness of the items for measuring general instructional conceptions in line with the design of pedagogical innovative interventions. It is suggested that a special validation study should be conducted on the general instructional conceptions questionnaire by using 1) participants from different countries at the same educational level, 2) same language for instructions, and 3) cognitive interviews. A similar study could be conducted by using a qualitative approach.

For the items measuring the specific instructional conceptions the opposite is to be concluded. For all scales high reliabilities are consistently found. Only two problems occurred in the Ghanaian study with respect to the conceived functionality of ‘computers’ and ‘project integrated activities’. For these two interventions reliabilities were lower than .70. A possible explanation is that these interventions are too broadly described.

The items of each scale of the specific instructional conceptions are homogeneous and therefore measure the same thing (construct/concept), i.e. the conceived functionality of that particular component of the innovative intervention (learning environment). This, unlike general instructional conceptions, suggests a clear indication that there are consistencies among the three countries in terms of specific instructional conceptions. The results support the research findings (e.g. Elen & Lowyck, 1999) that students have instructional conceptions about specific components of the learning environment. This, again, serves as evidence of vital importance of specific instructional conceptions in the design of innovative instructional interventions.

The results of these three reported studies suggest that general instructional conceptions are difficult to assess and that the presented instrument does not allow gathering reliable data on general instructional conceptions. On the other hand, for the specific instructional conceptions, it can be said that a reliable instrument was constructed.

This means that this questionnaire can be used for measuring conceptions on specific instructional interventions, and hence, provide an instrument that allows to gain insight into how students conceive of specific innovative instructional interventions. It allows researchers to estimate the moderating effect of innovative instructional interventions, and hence makes it possible to adapt the design of an innovative intervention to the control of these conceptions for acquisition of quality and productive knowledge and for development of expertise. Similarly, given the shortness of the instrument for these specific instructional interventions (8 items), a teacher can easily administer this instrument to gain insight into how students conceive of a specific innovative instructional intervention and hence compensate for possible non-compliant conceptions. Further validation studies are to be conducted to confirm the reliability of the questionnaire developed to measure students' general instructional conceptions.

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THE EFFECTS OF USING THE SHARE POINT PLATFORM IN TEACHING SCIENCE STUDENTS AND TEACHERS

Hanna Gulińska, Małgorzata Bartoszewicz
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ABSTRACT

The first models of distance learning ever came into being in the vast regions of Australia, USA and Canada where distances made it impossible for students to physically meet their teachers. This form of education was then considered to be a necessity and not an interesting variation of the traditional model. In last decades of the previous century, however, its advantages were also noticed in Europe. As a result so called open universities were founded such as the British Open University (1972), FernUniversitaet in Germany (1974), Universidad Nacional de Educacion a Distancia in Spain, Federation Interuniversitaire de l'Enseeigment a Distance – FIED in France and NETTUNO, a consortium of Italian universities which was created in 1990. Around the year 2000 distance teaching was used by some Polish companies, especially large corporations, as an alternative form of training. Since 2003 small and medium businesses have been implementing distance teaching as well. Currently, remote teaching - commonly known as e-learning - is being used in every area of social life, business and politics as well as in private lives of individual people. E-learning is being implemented in schools and universities (Okońska-Walkowicz A., Plebańska M., Szaleniec H., 2009 s. 33). In the academic year 2008/2009, the Microsoft SharePoint platform was used for courses carried out by the Department of Chemistry Education at Adam Mickiewicz University (AMU) in Poznań. The courses for the chemistry students were created by means of the available LMS tools. The same courses were taught to the students of the Faculty of Educational Studies as well as in-service science teachers. The courses were prepared by Professor Hanna Gulińska, Małgorzata Miranowicz, Ph.D., and Małgorzata Bartoszewicz, Ph, D. (Miranowicz, 2009).

KEY WORDS: E-learning, Blended learning, SharePoint platform, Students, teachers

1 Elementary education course

The course was taught to **forty** three students majoring in elementary education of the Faculty of Educational Studies at AMU in Poznań. All of the participants managed to complete the course. Some of them went through all of the modules of the course using the e-learning method. Those who encountered some difficulties decided to make use of planned consultations and thus finished the course by means of a blended learning method.

The course start window is shown immediately after the user logs in. The teacher, or any other registered person, may adjust the start window to their needs as well as the students' needs.



The class is started as a b-learning course. You will be using a remote learning platform called SharePoint on which this course is served.

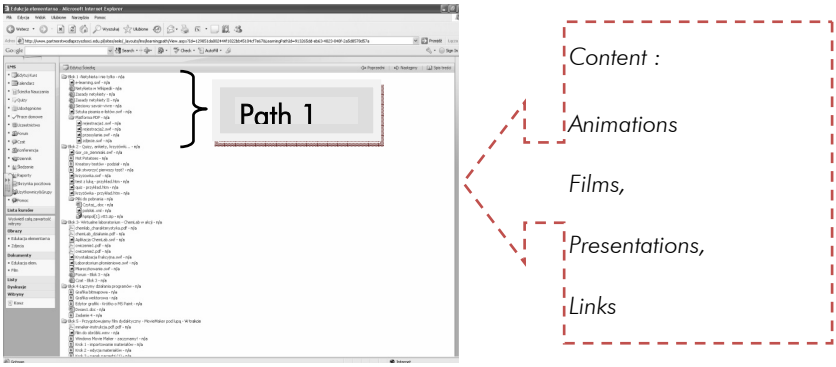
The course has been created according to the EU requirements concerning EQF and with a view to preparing you for continuous education.

All of the important information regarding the course is published in the Syllabus

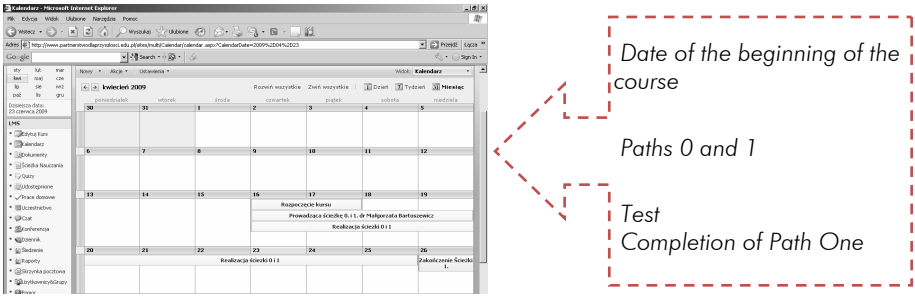
I wish you success,

Your Instructor
Małgorzata Bartoszewicz Ph.D.
goskab@amu.edu.pl

Educational Path presents the order of steps to be followed by each participant. The elements of the path might be of varied character. They may include documents and presentations which must be read by the participants, as well as links, animations, video sequences and quizzes which need to be done. The table of contents of the Educational Path looks as follows:

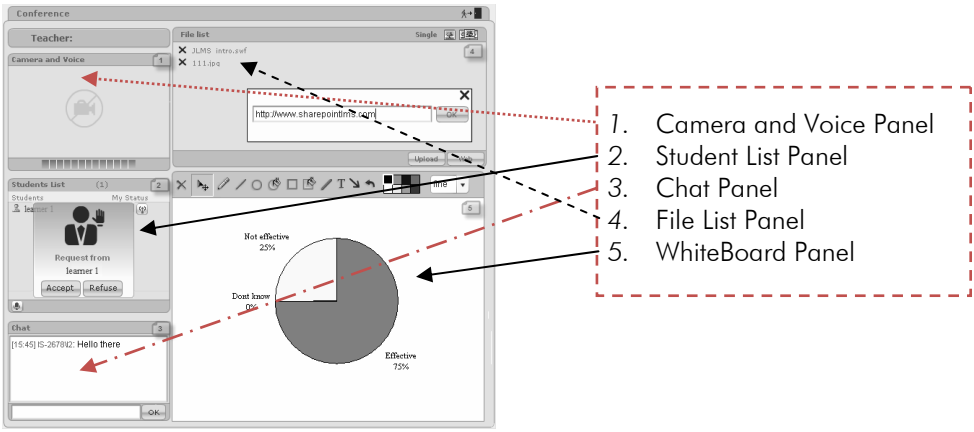


Calendar allows viewing and managing the events and meetings. The information about each date will be presented on the main page of the calendar as well as on the main page of the course. The use and setting of the calendar for Path One is presented below:



Conference – this option allows a better organization of the learning process. There are six elements in the Conference window**:** the **Record Panel** makes it possible to record a conference or its part, depending on the needs. The recorded materials are stored in the Conference file and may be played at any time. The **Camera and Voice Panel** presents video images form the instructor's camera and it can be connected to microphone and camera. The **Students List Panel** serves for checking which students participated in the conference. The **Chat Panel** is a platform for exchanging text messages between the users. The **File List Panel** makes it possible to work with files which are to be used during the conference. The **WhiteBoard Panel** constitutes the working area in

which graphic files and SWFs are presented. It may be used for drawing as well.



The syllabus of *Elementary Education* course

Kurs *Edukacja elementarna*



Elementary Education course

The course is taught to third year students of BA courses at Elementary Education at the Faculty of Educational Studies AMU in Poznań.

The classes are going to be taught in three five-hour blocks. Additionally the participants will be able to log in on the platform at any time and place in order to do their assignments remotely.

Cel kursu

The Aim of the course

The course is mainly aimed at raising the efficacy of educational work by applying IT tools which prove to be useful in teaching as well as by presenting the possibilities of e-learning and b-learning in life-long education.

The issues covered by the course within six blocks include the following:

- Block 1 **Nethiquette and more**
- Block 2 **Quizzes, questionnaires, crosswords…**
- Block 3 **ChemLab – virtual laboratory**

- Block 4 **Three in one or how to achieve synergy of different types of software**
- Block 5 **How to prepare an educational video – Movie Maker close-up**
- Block 6 **Power Point Animation**

Wymagania

Requirements

The requirement here is basic computer and Internet literacy. The participant should be able to use software for:

- making text documents (MS Office or OpenOffice),
- making basic graphic documents (Paint, Corel, Photoshop),
- viewing *.pdf files (Acrobat Reader),
- making presentations (PowerPoint).

Additionally, each of the participants must have their own mailbox.

System oceniania

Evaluation system

In each of the blocks you can get a maximum of 12 points, including 5 points for attending classes and 7 points for the assignments.

- Block 1 **Nethiquette and more**
- Block 2 **Quizzes, questionnaires, crosswords…**
- Block 3 **ChemLab – virtual laboratory**
- Block 4 **Three in one or how to achieve synergy of different types of software**
- Block 5 **How to prepare an educational video – Movie Maker closeup**
- Block 6 **Power Point Animation**

Additionally each participant can get:

- max. 10 points for adding a photo in their user profile on the platform. The photo should show the face of the user (the participant).
- max. 5 points for filling in an evaluation questionnaire after the course.

Points to be obtained	**total**
6 blocks x 12 points	72
Adding a photo	10
Filling in the questionnaire	5
Maximum score to be obtained in the course	**87**

Points:	**Grades:**
80-87	Very good
76-79	good+
73-75	good
66-72	satisfactory+
51-65	satisfactory

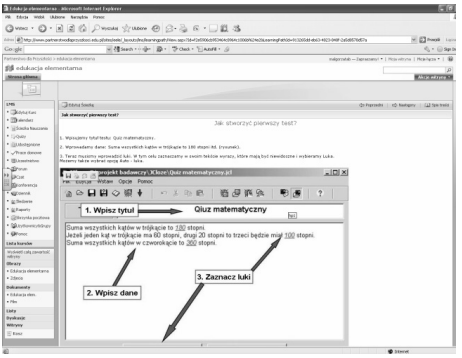
Kontakt

Contact person
Małgorzata Bartoszewicz
E-mail: goskab@amu.edu.pl
Telephone. (061) 8291371

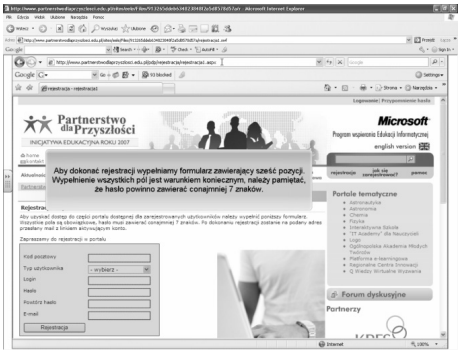
Within each thematic path there were materials in the form of:

– contents presented directly on the SharePoint platform *including screen prints, photos and explanations:*



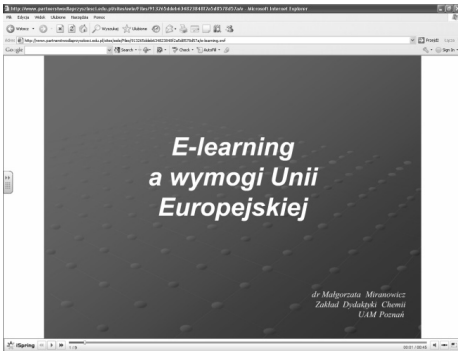


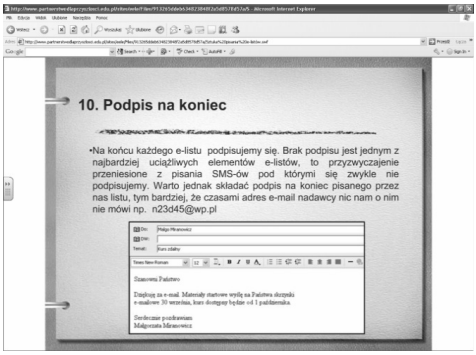
– short instructions, e.g. animations (*each participant could watch a simulation of the software, experiments, phenomena, manners of creating multimedia materials*):



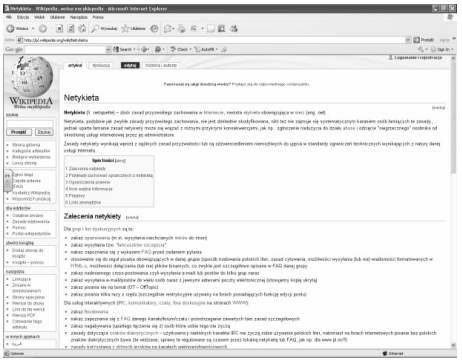


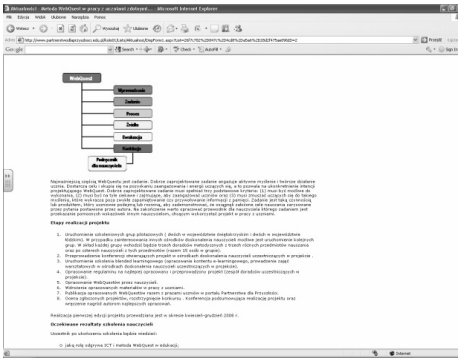
– thematic presentations with a soundtrack or comment to every slide:



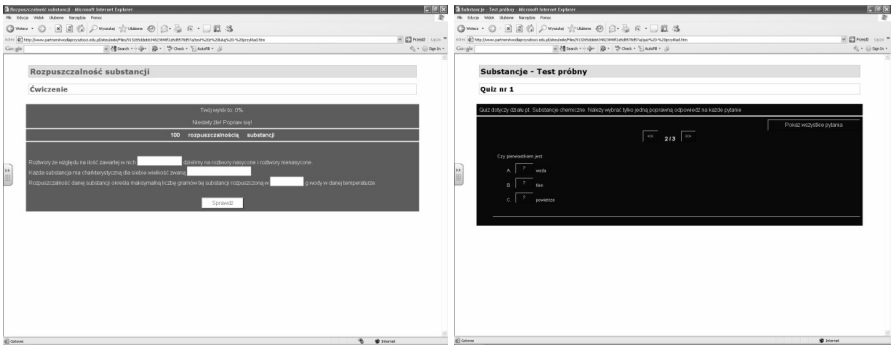


– links to Polish and foreign websites *presenting interesting articles on given topics, definitions, examples connected with the theme, interesting facts, etc.*

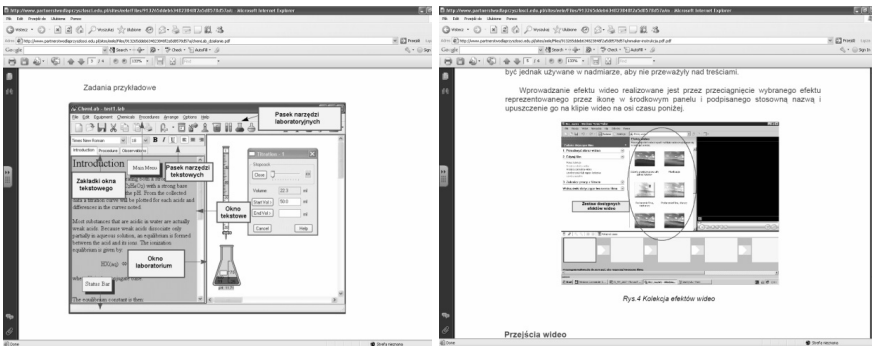




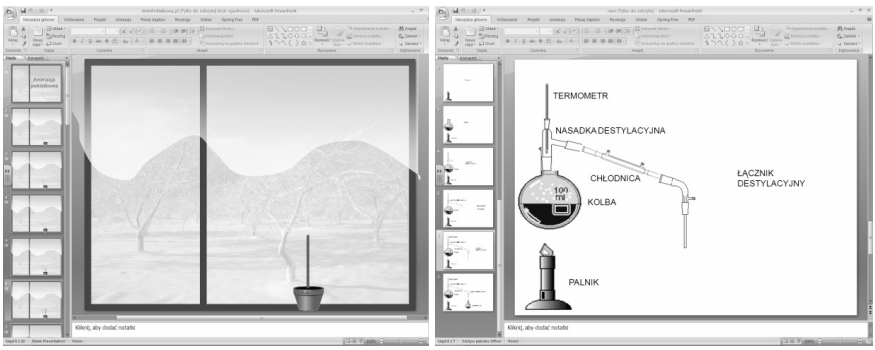
– interactive exercises where *the students had to fill in gaps, choose the correct answer, do a crossword puzzle, prepare an apparatus for a particular science experiment etc.*:



– PDF documents; *students can print the instructions, especially those for software tools*:

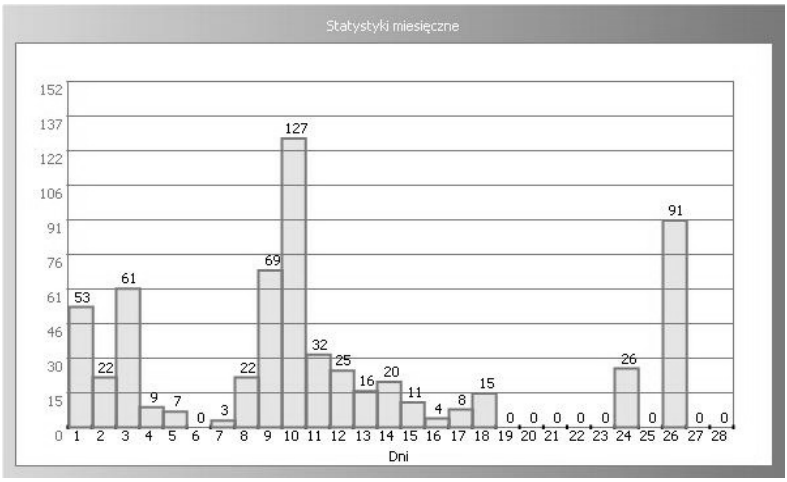


– Time lapse animations *showing the course of natural processes and experiments (prepared by means of popular software, e.g. Power Point 2007):*

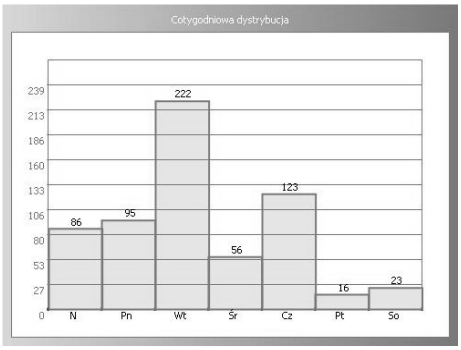


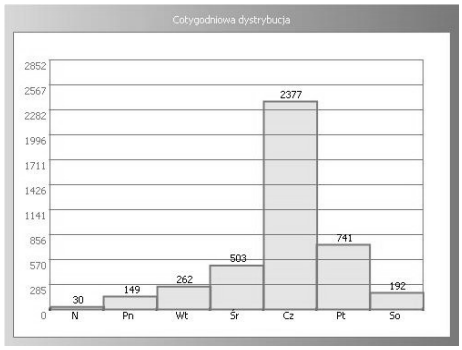
The students worked in the most convenient time and place, which has been confirmed by the course statistics:

– Monthly events of logging in to the course:



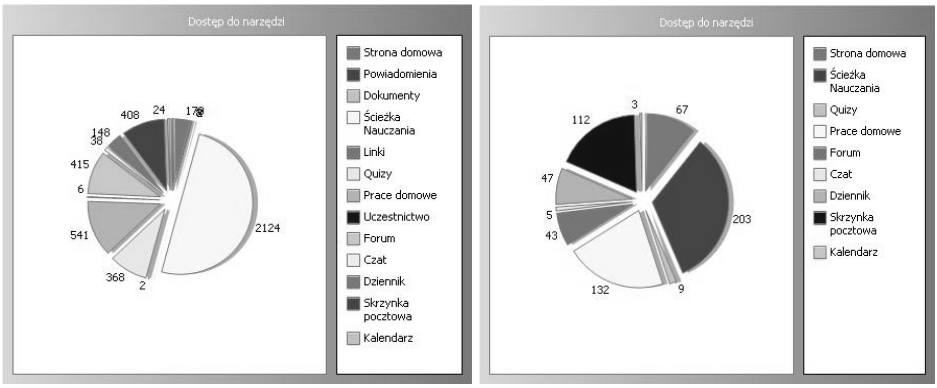
– Weekly events of logging in to the course on particular days of the week:





The events of logging in to the platform were not evenly distributed during the course.

Most frequently used tools in Share Point:

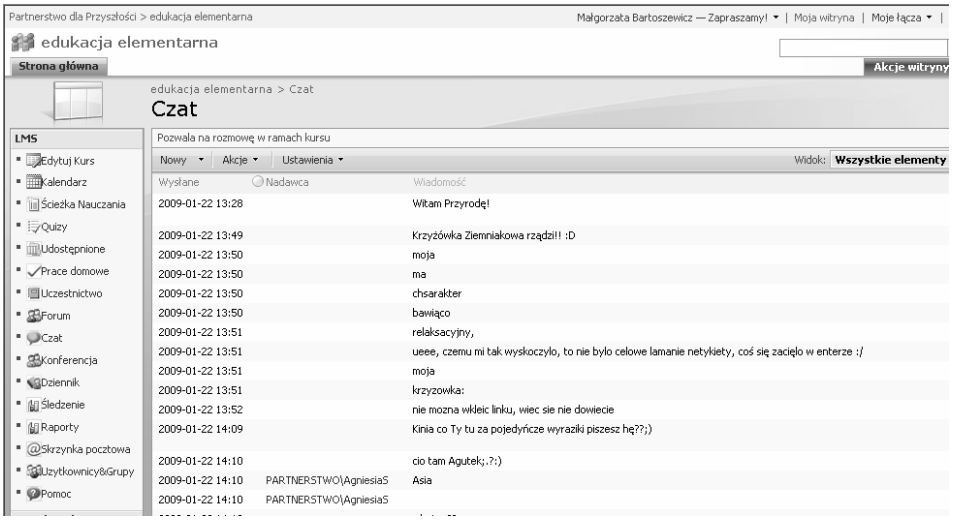


The students most frequently used:

– *Teaching path* where they could find all the course materials,
– The *Homework* bookmark
– *Mailbox* which was used for sending their assignments to the instructor as well as their messages to the other participants of the course.

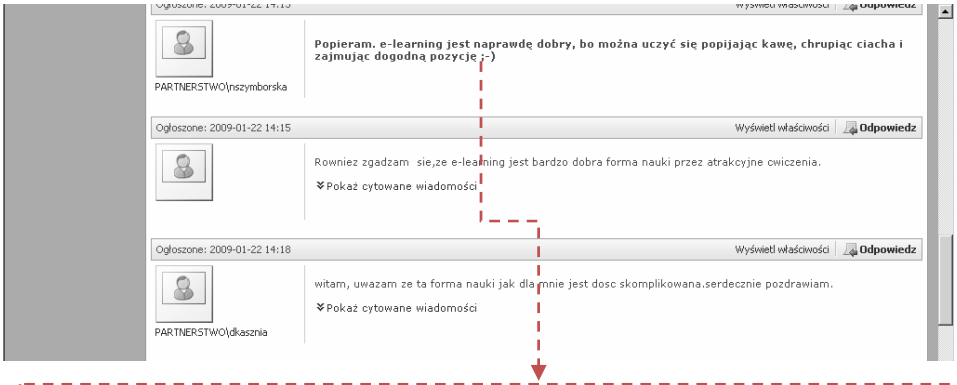
Forum and *Chat* were used for communication

A chat window- small talk:



a *Forum* window

a) e-learning as a new form of education – students' opinions:



I am definitely for e-learning. It is really great. You can assume the most comfortable position, sip your coffee, munch your favorite cookies and at the same time study.



Hi Girls, time for my opinion and comment. Well, to start with, many thanks to the authors of this course. This must have been a great task and I admire the effort they must have made. Bravo! For us, teachers-to-be, this is a brand new and extremely interesting idea for learning some new teaching methods, for constructing tasks in worksheets and a simple way to learn the complexities of computers (believe me I know everything about how complex this can get!). On the other hand, no matter how useful the course seems to be, it does not have the typically educational features which might help us teach young kids such things as education and cognition. I can only see here a new way of using the computer, expanding one's knowledge and skills within information technology. That's all what I wanted to share with you.

2 Summary

The completion of the course by all of the participants is a great success especially because their computer skills were initially quite poor. Their enthusiasm evoked by passing subsequent blocks and the perseverance of the external instructors was the main reason why their final assignments received very high marks (good, good+, very good) and only one person received a satisfactory mark. The most difficult problem to overcome for the participants was not the e-learning platform itself, but effective time management.

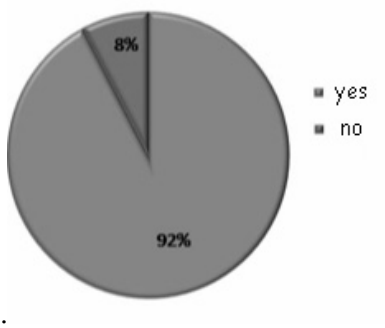
The participants filled in the following questionnaire:
Please underline an answer - yes or no
Please provide your answer to the open questions. Send the questionnaire by LMS to *malgorzatab* as an attachment. Best regards

Małgorzata Bartoszewicz

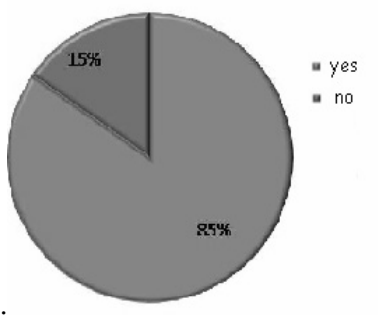
Here are the results of the survey:

1. Did you have a mailbox before the course?
2. Was this course the first opportunity for you to encounter a distance learning platform?

1.

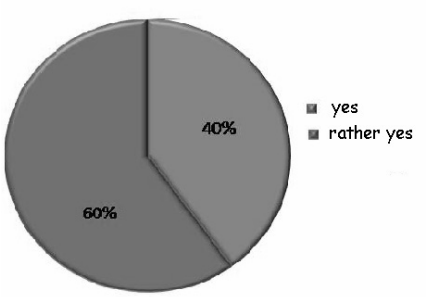


2.

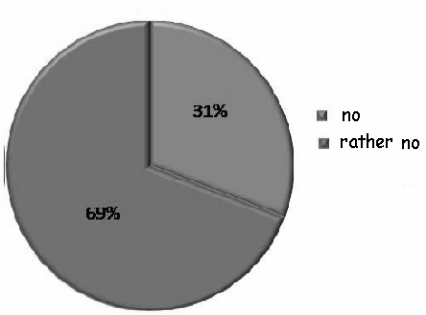


3. Was the material presented in the course easy to follow? (yes, rather yes, no, rather no)
4. Did you have any problems using the platform? (yes, rather yes, no, rather no)

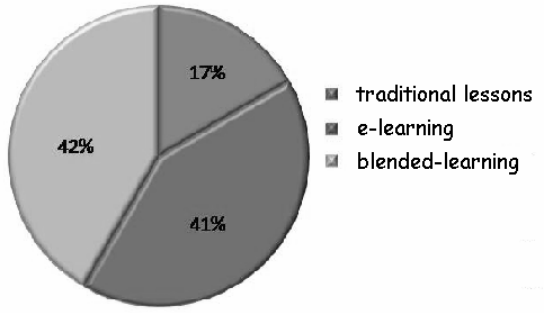
3.



4.



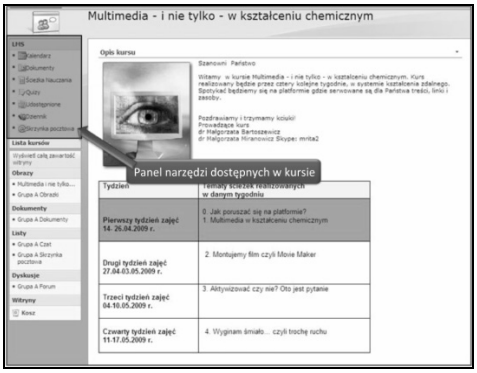
5. I prefer: traditional lessons, e-learning, b-learning



6. How do you evaluate the work on the platform?
 The platform was a new thing for me, still I did not find it very difficult to work on it. It is an interesting alternative.
 Interesting. I give it a 4+
 An ideal form of work for me, the platform is convenient, easy to use, most of the tasks are on an appropriate level.
 At the beginning, the tasks seemed to be very difficult and problematic, however, after some time I got used to them and it was much better☺
 The work on the platform seems to be very interesting for a teacher-to-be, it helps prepare many interesting didactic materials. However, as far as students' work is concerned, I think that it should not be done on the platform. It would simply leave no space for experiments and learning the world by means of the senses and independent problem solving.
 It seems that a child has no opportunities to be really close to Chemistry on the platform.
 I did learn a lot and I am very pleased to have participated in the classes carried out on the platform.

The students' opinions expressed in the questionnaire as well as during the summarizing class point to the fact that this form of learning is widely accepted and treated as a consequence of advancement in IT. Most students would like to participate in another similar training to raise their professional qualifications.

The interest in distance learning seems to be confirmed by a vast number of participants of the Multimedia and more in chemistry education course. It was a four week fully remote course via Microsoft SharePoint. It was dedicated to all those who work in science education, who want to expand their experience and learn how to prepare multimedia materials for science classes. The theoretical content related to the strategy of implementing multimedia in chemistry education was prepared by Professor Hanna Gulińska, and the classes were taught by doctors Małgorzata Miranowicz and Małgorzata Bartoszewicz.



Both editions of the course were accepted very well by the participant, which was reflected in the questionnaires filled in after the course by the participants as well as in their opinions expressed in chats and e-mail messages sent directly to the instructors. Each participant could see for themselves what the advantages and drawbacks of this form of training were.

The following advantages were most frequently mentioned:

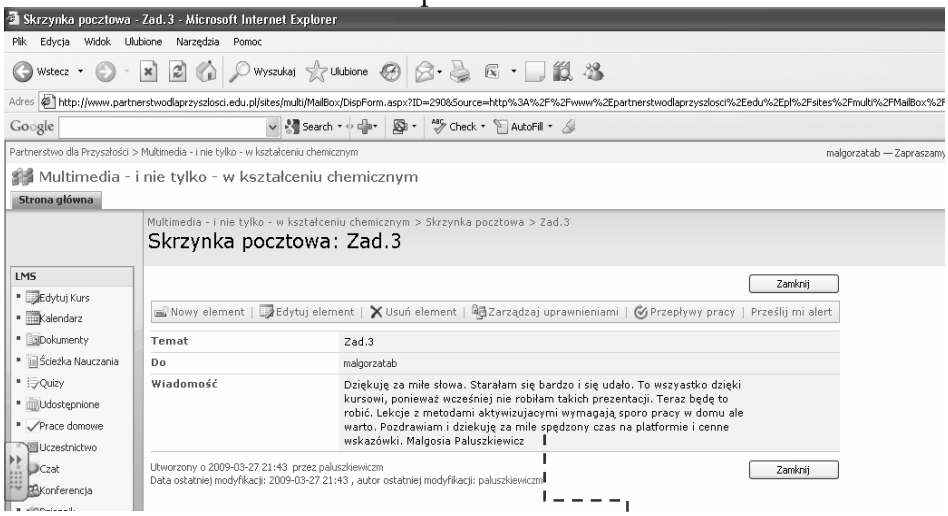
- the opportunity to learn regardless of age, education, residence and family circumstances;
- more independence for the participants,
- free choice of the place of study (home, office, sofa, desk),

– the pace of learning adjusted to individual needs ,
– abundance of teaching aids.

Among the drawbacks of this form of learning the participants pointed out:

– the feeling of loneliness,
– no direct contact with the instructor and other students,
– decreased motivation and perseverance
– independent time management.

Here are some of the students' opinions:



Thank you for your nice words, I did try my best and I succeeded. And all this thanks to the course as it was the first time I ever made a presentation. From now on I am going to make many more. The lessons with activating methods require quite a lot of preparation but they are definitely worth the effort. Best regards and thank you for the nice time I had during the course and your valuable advice.

Małgosia Paluszkiewicz



Hello, I would like to thank you for the four weeks of the course on Multimedia and more... Thanks for the assignments and clear instructions. I had not been so sure that I could manage, yet I did. I am glad to be able to use the information and skills in my work with students. I admire your work and I am very grateful for the things I learned during the course. This is a very good and sensible education which should be continued. In spite of the fact that everything takes place in virtual and remotely controlled world, each of us exists in reality. It is very good that you took up this type of teaching. I wish you lots of good health, power and success in your private and professional life.

Elżbieta Utig

And some forum posts:

- This course was an excellent idea and the implementation was just great, all the best :).
- I would like to participate in distance courses organized by your team once again. I teach in a school for young hospital patients and I need many activating methods as I deal with kids waiting for operation or those very weak after the operation.

The group of e-learning enthusiasts is growing, but there are still quite a few obstacles to be overcome. Not many people are able to imagine that a traditional classroom could be replaced by a virtual one or that the

virtual course instructor could compete with the traditional education with regard to quality and efficiency. On the other hand, this form of learning is much cheaper and very effective. The biggest hindrances now are a lack of knowledge about the real potential of such tools as platforms and fear of the unknown. A well prepared and carried out virtual course which employs the latest developments in distance teaching, with the possibility to interact by means of voice, images and teamwork can not only compete with the traditional education but it may also be much more effective when combined with some elements of traditional education.

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FOSTERING TEACHER INNOVATION IN CHEMISTRY TEACHING IN THAILAND:

Helping Thai Science Teachers Move Towards a Learner-Centred Student Classroom

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ABSTRACT

Thailand like many countries worldwide has engaged in major reforms to the science curriculum. A key focus of these reforms has been a shift towards a learner-centred science curriculum. However, few Thai science teachers actually know what a learner centred classroom looks like, or know how to develop learner centred pedagogies. In this chapter we report on a number of studies sponsored by the Thai Government, many working through the Institute for the Promotion of Science Education, and show how a learner-centred science curriculum in Thailand has been developed. The pedagogies employed to foster active learning are detailed along with a consideration of the value of such pedagogies.

KEY WORDS: Learner-centred student classroom, Teacher innovation, Active learning, Curriculum reform

1 Introduction

As a result of substantial curriculum reforms, teaching and learning in Thailand, as in many countries worldwide, is now supposed to be learner-centred in nature, and to employ innovative teaching approaches that meet learner's needs. But how learner-centred are Thai classrooms, and what pedagogies do Thai teachers use to foster innovative learning in Thai chemistry classes? When Thailand reformed its curriculum, including the science curriculum, the Institute for the Promotion of Teaching Science and Technology (IPST) was charged with leading the implementation of the reforms, and much local research has since been conducted about the implementation of learner-centred education. In this work we attempt to answer the two questions posed above, by reporting on three studies conducted by Thai researchers. We begin with a brief overview of the Thai curriculum reforms, and then discuss the teaching of some specific chemistry topics. We provide a brief overview of the literature, and describe what has been reported as difficult about teaching and learning of these topics. Next we describe the Thai context, as it relates to the teaching of the topic, and describe the leaner-centred pedagogies developed in Thai-based research. We conclude by describing the findings and consider what they have to tell us about learner centred education used to foster innovative chemistry learning in Thailand.

2 Curriculum reform in Thailand

Thailand's educational reform was driven at least in part by the so-called Asian economic crisis of the late 1990s. This crisis resulted in the formation of a perception by the Thai government at the time of an urgent need to develop Thai peoples' ability to keep up with the rapid change characterized by mass globalization. As a consequence the 1999 National Educational Act was developed under the provision of the 1997 Thai Constitution. The key issues for education reform identified in the 1999 National Education Act are: expanding basic education from 9 to 12 years of schooling, and extending compulsory education from 6 to 9 years of schooling; providing education to meet learners' basic learning needs, upgrading their skills, and encouraging their self-development;

implementing internal and external quality assurance systems in schools and education institutions; reforming administration and management of education to encourage full participation of local educational authorities and local community; encouraging private sector participation in educational provision; reforming pedagogy by emphasizing learner-centred activities and establishing life-long learning; reforming the curriculum, allowing for the contribution and participation of stakeholders, to meet new challenges and demands of different groups of learners with an emphasis on mathematics, science, and technology in parallel with the promotion of pride in national identity and cultural heritage; and reforming resource allocation at the national level on the basis of equity and encouraging local educational authorities and communities to mobilize their resources for education (International Bureau of Education, 2004). As of May 2004, basic education was extended from 12 to 14 years including two years pre-primary schooling (Ministry of Education [MoE], 2004).

2.1 Thai School Structure and Curriculum

In the Thai education system, the school structure of the basic education as at 2008 is divided into five levels: two years of pre-primary (K1-K2); three years of lower primary (G1- G3); three years of upper primary (G4 – G6); three years of lower secondary (G7 – G9); and, three years of upper secondary schooling (G10 – G12). Schooling at Grades 1 to 9 is now compulsory (Office of the Education Council [OEC], 2006). There are two curriculum documents that detail the curriculum for basic education: the 2003 Pre-primary Curriculum, and the 2001 Basic Education Curriculum (OEC, 2006). The 2001 Basic Education Curriculum specifies learning is to occur over eight subjects: *Thai Language*; *Mathematics*; *Science*; *Social Science*, *Religion & Culture*; *Health & Physical Education*; *Art*; *Career & Technology*; and *Foreign Languages*. English is part of the core curriculum for foreign languages, and is required at all levels (MoE, 2002). The 2003 curriculum for pre-primary education focuses on preparing children in terms of their physical, intellectual, emotional/mental and social readiness (OEC, 2006). In a revision in 2008, the curriculum was called the "core curriculum 2551" or B.E. 2551 (MoE 2009). The content and standards remain the same, with lower grades combined into G1 – G9, that is, one grade level.

These national curricula act as a guide for schools, who are expected to construct their own school–based curriculum. The school–based curriculum is described as a 70:30 model, in which 70% of the content is derived from the national curriculum, and 30% from school contexts. Schools are expected to cooperate with individuals, families, community organization, local administration organizations, private person and organizations, professional bodies, religious institutions, enterprises, and other social institutions in order to strengthen their communities by encouraging learning in the communities themselves (National Education Act, 1999, Section 29).

3 Teaching dilution chemistry in Thailand using authentic, laboratory-based, teaching approaches

Under the Thai educational reforms teaching and learning activities are expected to be learner-centered, involve learning by doing, and have students engaged in learning activities that involve authentic learning. This is taken to mean students learn by engaging problem-solving activities that integrate with questions and problems in daily life. Authentic learning, according to Collins et al. (1988, p. 2), involves "learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life". Teachers need to design activities in which "students can integrate needed knowledge, skills and attitudes, coordinate individual skills that comprise a complex task and transfer their school learning to life, or work settings" (Rule, 2006, p. 1). Rule (2006) classified four types of authentic learning: 1) the activity involves real-world problems; 2) open-ended inquiry, thinking skills, and metacognition; 3) to discourse and social learning; and 4) selected topic that learners' interested (Rule, 2006). Callision and Lamb (2004, cited in Rule, 2006) identify seven indications of authentic learning: 1) student-centered learning; 2) accessing of multiple resources beyond the school; 3) students as scientific apprentices; 4) the opportunity to gather original data; 5) lifelong learning beyond the assignment; 6) authentic assessment of process product and performance; and 7) team collaboration.

The literature suggests that practical work is a way we can enhance student leaning and enjoyment of learning science (Nakhleh et al., 2002), but that students are often not interested in practical work that is not related to daily life. In Thai universities a large number of first year students study general chemistry, and do many experiments. The general chemistry course for first-year student covers the following topics: atomic structure and chemical bonding; states of matters and solutions; stoichiometry; chemical thermodynamics and kinetics; and chemical equilibrium. Students find it difficult to understand some topics, such as solutions, stoichiometry, chemical equilibrium, and ionic compounds, because they are abstract problems and not related to everyday life (i.e., they are not authentic), and that they require students to solve numerical problems. Here we describe innovative teaching of dilution chemistry. In most laboratory experiments students need to be able to make up solutions, and often make diluted solutions from standard stock solutions (e.g., when doing titrations, Dunnivant, Simon, & Willson, 2002; McElroy, 1996; Wang, 2000), but it is not immediately obvious how we might relate such activities to everyday life – that forms the basis of this work, which also is based on the three levels of understanding.

Understanding dilution requires understanding of a series of related concepts: concentration, solvent, solute, solution, solubility, and the mole. So in order for students to understand dilution they need to understand the mole concept, as well as the concepts of solution and concentration. Additionally, these topics require knowledge of more simple concepts such as volume, molecules, and the use of equations. Hence, for students to understand dilution they need to understand concepts and models at both the macroscopic microscopic and symbolic levels, and to be able integrate across the three levels of representation (Heyworth, 1999; Johnstone, 1991; Larkin, 1983). The mole is an abstract concept at the microscopic level, but a concept that also establishes a connection to amounts of substance at the macroscopic level (Staver & Lumpe, 1995). The mole is a concept that the literature suggests students have many difficulties understanding (Case & Fraser, 1999; Heyworth, 1999; Novick & Nussbaum, 1976; Staver & Lumpe, 1995). It seems this is at least in part due to poor understanding of the definition of the mole, and overuse of formulae for solving mole-based problems (Furió et al., 2000). Students' definitions of the mole vary substantially (Staver &

Lumpe, 1995), and, for example, the mole is thought by some students' to be restricted to the numerical concept (i.e., the mole is a number, Staver & Lumpe, 1995).

The literature suggests that students' ability to understand mole concept depends on their understanding not only of mass and volume, but also about the particle nature of matter. Likewise, solution concepts are more complex than mole concept, because students need to understand both solution process, and the idea of concentration (Gabel & Bunce, 1994). Students' understanding of solution concepts depend on their understanding of underlying concepts such as: solution, solvent, solution and homogeneity. It seems that at the secondary school, they understood only vaguely the terms solvent, solute, and solution, but are able to distinguish between homogenous and heterogeneous mixtures (Çalik & Ayas, 2005). In order to fully understand dilution then, students not only understand the concept of dilution but also need to understand three key concepts: mole, solution and concentration. Students have great difficulty in understanding the mole and related concepts at macroscopic level, and also find it hard to relate to the microscopic level, to describe such ideas at the symbolic level, and to relate this to the macroscopic and microscopic levels. Students deal with this by avoiding dealing with concepts underlying dilution; instead resorting to the use of a simple dilution equation such as $C_1V_1=C_2V_2$. Strict adherence to such equations means students seldom understand much about the amount of substance, and the concentration present before and after the dilution of solutions (Demeo, 1996; Raviolo, 2004). In other words, students may be able to solve numerical problems using algorithm – meaning it looks like they understand dilution, but often fail to learn the concepts– meaning they cannot solve new problems (Çalik, 2005; Case & Fraser, 1999; Dahsah & Coll, 2007a, 2007b; Pınarbasi & Canpolat, 2003; Schmidt & Jignéus, 2003).

In research based in Thailand, Jansoon, Somsook and Coll (2008) designed a new experiment to motive first year undergraduates students in general chemistry laboratory classes using real-world problems and collaborative group work. Green tea something that is widely consumed in Thailand, was used as an authentic, real-world example. Green tea contains a variety of chemicals – known as phenolic compounds (e.g., epicatechin, epicatechin, epicatechin gallate & epigallocatechin gallate).

The experiment was designed to determine total phenolic compounds in green tea beverage samples that as the way as scientists do (using the well-established Folin-Ciocalteu method). The teacher introduced the topic, and the students choose their own green tea beverage sample. The experiment employed the Jigsaw approach, and hands-on activities consisting of three things: a laboratory activity related to a real life problem; collaborative group work; and the development of thinking skills (Jansoon, Coll, & Somsook, 2009; Jansoon, Somsook, & Coll, 2008). Students did the laboratory work at the macroscopic level, and illustrated their understanding of the chemistry in their ability to use a particular theory at the sub-microscopic level. At the symbolic level, students were able to successfully do dilutions involving the use of chemical symbols and mathematical equation. The students' mental models of dilution and related concepts were elicited and examined in terms of their ability in using representation of chemistry. In laboratory report, they were asked the six questions to make the drawing in macroscopic and microscopic levels and to solve the mathematic problem in symbolic level. Finally, they integrated and connected the three levels of representation. The six questions were asked to determine the total phenolic compound in 500 ml of green tea beverage:

1. What is the equivalent concentration of total phenolic compound in the solution measured by Spectronic 20?;
2. What is the amount of phenolic compound in 25 ml of green tea solution?;
3. What is the amount of phenolic compound in 1 ml of 10% green tea beverage?;
4. What is the amount of phenolic compound in 100 ml of 10% green tea beverage?;
5. What is the amount of phenolic compound in 10 ml of green tea beverage?; and
6. What is the amount of phenolic compound in 500 ml of green tea beverage?

So they were asked questions and made drawings of what they thought was happening at the macroscopic and microscopic levels, and had to solve some quantitative problems at the symbolic level. In addition, students' understanding was elicited using the interview-about-events technique (IAE). Three approaches were together used to investigate the

students' mental models: open-ended questions; drawing with description; and interview data.

Examination of laboratory reports reported in Jansoon (2009) revealed that students typically represented their understanding by using mathematics to calculate the total phenolic compounds in green tea beverage samples at the symbolic level. Students' understanding of the six dilution questions revealed some interesting findings. It was noted that students who responded to the questions using all three 'thinking levels' overall showed a better understanding off dilution (Figure 1), suggesting that integrating thinking across the levels, rather than simply using an algorithm resulted in better learning.

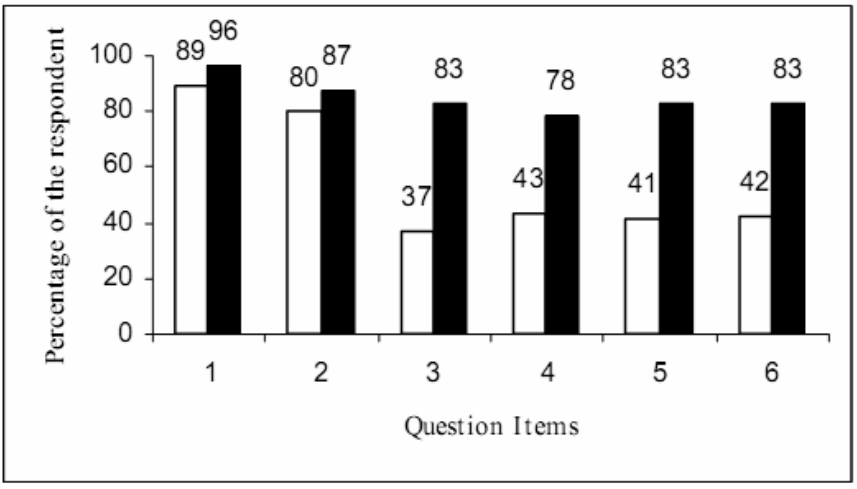


Figure 1. Proportion of students' correct answers based on whether or not they used all three 'thinking levels' of chemistry to solve dilution chemistry problems

Some students who were not able to evidence understanding at the three levels of representation, were able to do simple numerical problems, for example to determine the concentration of phenolic compounds from a calibration curve and calculate the amount of total phenolic compound in 25mL of solution(see Question Items 1 and 2 and Figure 1). This is a simple mechanical task rewarding students who like to use formulae, as

noted above. However, for more complex tasks as probed in the Items 3-6, less than half of such students could get the correct answers; indicative of poor understanding of dilution concept, meaning they had used, say the dilution equation, without actually understanding the concepts. In contrast, students' performance was thus dramatically improved if they could understand and integrate the three levels of chemistry representation (Jansoon, 2008, 2009). Similar results were seen for other more cognitively challenging tasks like choosing dilution methods, determining solution concentration, using a UV-Vis spectrometer, producing a calibration graph, and calculating the phenol concentration in green tea. However, an interesting artifact of the intervention was that less than half of the students said they liked the Jigsaw classes and were happy and relaxed in their class. This was a key tool in helping them to act as a scientist by becoming an expert, and defending their views to their group peers and in a whole class setting. When probed, some students said not only they did not really understand the Jigsaw IV method, and they felt they could not manage time and their groups generally. This is most likely because this method was used for the first time in these experiments.

3.1 Conclusions and Implications

Treagust, Chittleborough, and Mamiala (2003) comment that students needed to be able to link the macroscopic level with the microscopic and symbolic levels, if they are to shift from instrumental understanding to relational understanding. In order to lead to depth understanding in dilution and related concept, here students were encouraged to develop their mental model in the manner consistent with scientific consensus models (Jansoon, Coll, & Somsook, 2009). The research reported here indicates that as a result of the Jigsaw method and an authentic laboratory activity, the students' understanding and ability to integrate the three levels of representation for the topic of dilution was enhanced.

4 Teaching the mole concept with analogies

The mole is one of the seven base units of the SI system and is defined as the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kg of carbon-12. As Kolb (1978, p.

728) states "there is probably no concept in the entire first year chemistry course more important for students to understand than the mole. The main reason that the mole is so important is mole is used to define the relationship of the amount of substances in chemical reactions. The relationship between mole and mass, number of particles (atoms or molecules), or volume of a gas at STP is:

- the mass of one mole of any substance is numerically equal to the atomic mass, molecular mass, or formula mass of the atom or molecule in grams;
- one mole of all substances contains an Avogadro's Number (6.02×10^{23}) of particles; and
- the volume of a gas at constant temperature and pressure is directly proportional to the number of molecules of the gas. One mole of any gas has a volume of 22.4 dm^3 at STP, or the molar volume of gas is 22.4 dm^3 at STP.

In the Thai Science Curriculum the mole is a topic taught at Grade 10, and the learning outcome is "define relationship and convert between mole, number of entities, mass, and the volume of gas at STP".

4.1 Students' Difficulties in Learning the Mole

A number of researchers have investigated students' alternative conceptions for the mole, and, not surprisingly, students lack a scientific conception of the mole (BouJaoude & Barakat, 2000; Gabel & Bunce, 1994). According to the literature, the five most common student alternative conceptions about the amount of substance and mole are:

- Students lack a scientific concept of the mole;
- Most students identify the mole with a mass, a volume and/or a number of entities;
- Students do not identify the mole as the unit of amount of substance;
- Students frequently make mistakes about the macroscopic level of representation of a substance with the microscopic level of atoms and molecules; and
- Students usually identify the proportion of the number of molecule with the proportion of masses, and molar masses (Furio et al., 2002).

Research in Thailand by Dahsah and Coll (2008) explored Thai high school students' understanding of the mole and related concepts, and indicated that, as reported elsewhere, many students hold alternative conceptions in the mole concepts, such as:

- one mol is one molecule (also found in Thirasiri, 1990);
- atomic mass and molecular mass are the mass of one atom, and one molecule respectively (also found in Thirasiri, 1990);
- one molecule is equal to 6.02×10^{23};
- the molar mass of the compound is equal to 6.02×10^{-23};
- one mole of all substances always contains 6.02×10^{23} atoms;
- a mole molecule of S_8 contain 8 atoms;
- substances that have the same mass in grams, contain the same number of entities;
- At STP, 1 mole of any substance has the volume of 22.4 dm^3; and
- any substances that have the same volume, will have the same number of moles.

From the examples above, it seems that students do not understand the mole concepts (mole, molar mass, molar volume), or the relationship between the mole, particle, mass, and volume of substance.

4.2 Analogies for the Mole

Analogy is one of the most popular strategies used to introduce students the mole concepts, because analogy can be used to connect the new concepts that are not familiar to students with their existing conceptions or familiar examples. This helps students to understand the new concepts more easily. Some analogies that the literature proposes to facilitate student familiarity with the mole are:

- the preparation of a fruit salad of equal number of grapes and cherries to introduce the concept of same number of entities, different mass (Felty, 1985);
- using a chart mnemonic to help students to understand the concept of the mole by seeing the amount of a substance in three familiar ways, everyday measure; mass (e.g., a kilogram of butter), volume (e.g., a liter of milk) and numbers (e.g., a dozen eggs) (Brown, 1991);

- calculation of the thickness of the layer of one mole of small particles of confectionary such as M & M's that cover large areas (Merlo & Turner, 1993);
- calculation of the time that money will run out if spending one million dollars every second, supposing an initial amount of one mole of dollars (Tannenbaum, 1990);
- calculation of the volume occupied by one mole of small particles such as marbles, sand, grains (Hoyt, 1992);
- calculation of the volume and mass of a mole of ants and grain of sand (van Lubeck, 1989);
- comparing the magnitude of Avogadro's number with the volume of the Pacific Ocean, expressed in millilitres (Alexandre, Ewing & Abbott, 1984);
- calculation of the volume of the Avogadro's number of drops of water (Fulkrod, 1981);
- counting a large jar filled with jelly beans by weighing, introducing the transfer between mass and number of particles (Dominic, 1996); and
- using coloured gas cans and gas cubes to visualize the laws of Gay-Lussac and Avogadro (Bouma, 1986).

In this work the authors (Dahsah, 2007) we developed and adopted some analogies reported in the literatures and used these in activities to introduce the mole concept.

1. Number of small particles
 Objective: to introduce the relationship between mass and numbers of entities.
 Materials: jars of green beans, balances
 Activities:
 - separate students into group of three
 - each group of students designs the fastest way for counting numbers of green beans in a jar
 - students count numbers of green beans using the method that they designed
 - share and discuss with a class

Conclusion: The fastest method for counting numbers of green beans is weighing. Students count some of the green beans and weight it. Then weight all the green beans in the jar. Then, calculate the numbers of green beans in a jar by using the proportion of the mass and number of green beans.

Discussion: The size of atoms and molecules are too small, so we could not count it so chemists weight the substance and use it to convert to the numbers of entities because they know that all substance that has mass equal to it molar mass always contained 6.02×10^{23} entities.

2. Mass of one mole

Objective: to introduce the relationship between mass and mole.

Students' alternative conception:

- substances that has the same mass in grams contain the same number of entities
- atomic mass and molecular mass are the mass of one atom and one molecule respectively.

Materials: green beans, red beans, black beans, beakers, balances

Activities:

- separate students into group of three
- each group of students finds out the weight of the same numbers of green beans, red beans, and black beans, respectively
- students calculate the mass of one particles, and one mole of green bean, red bean, and black bean (teacher should suggest students that one mole of substance contains 6.02×10^{23} entities)
- share and discuss with a class

Conclusion: The same number of different beans has different mass. The mass of one bean is not equal to the mass of one mole of beans.

Discussion: Different substances have different mass. The mass of one entity is not equal to the mass of one mole. In addition, the substances that have the same mass in grams do not have the same number of entities (except the one that has same molar mass). The teacher also could tell students that the mass of one mole of substance is "molar mass".

3. Size of Avogadro's number

Objective: to introduce the size of Avogadro's number.

Students' alternative conception:

- one mole is one molecule
- one molecule equal to 6.02×10^{23}
- the molar mass of the compound equal to 6.02×10^{-23}

Materials: paper clips; stopwatch

Activities:

- separate students in group of two
- one student count 100 paper clips and another records the time,
- repeat three time and find the average time
- calculate how long needed to count one mole of clips (i.e., 6.02×10^{23} paper clips)
- share and discuss ideas with the class

Conclusion: The approximate time for counting one mole of paper clips is 10,000,000,000,000 years.

Discussion: Avogadro's number is a huge number, which is not possible to count. That why the chemists use the unit of moles to describe the amount of substances.

4. Volume in one mole

Objective: to show the relationship of number of substance and its volume.

Students' alternative conception:

i. at STP, 1 mole of any substance has the volume = 22.4 dm^3
ii. any substance that have the same volume will have the same number of moles

Materials: film boxes, green beans, sand, rice

Activities:

- separate students into groups of three
- fill green beans, sand, rice in a different film boxes with equal volume
- count numbers of particles of each substance
- share and discuss in a class

Conclusion: There is different number of particles in each substance even they have the same volume.

Discussion: Students may not be able to count the numbers of sand in the boxes; however, they could tell that the numbers of sand is much more than rice and green beans. For this activity, students will realize that different amount of substance may not have the same volume. After this activity, teachers can give students worksheets asking them to calculate the volume in one mole of different substances in different phases (solid, liquid, and gas) by giving them molar mass and density of each substance at STP. Students can thus see that only in gas phase, one mole of substance has an equal volume, and it is 22.4 dm^3 at STP.

These analogies were implemented in three Grade 10 science classrooms in three different schools by three volunteer teachers (all females) experienced in teaching chemistry at high school level (for 20+ years). Each analogy was used as an activity mapped in the large scale of the learning process. The learning process used in the study was based on conceptual change learning approach proposed by Stephans (1994), which includes five steps to learning: express ideas, share ideas, challenge ideas, accommodate ideas, and apply ideas. The detail of the learning process are provided in Dahsah (2007), and Dahsah et. al. (2009).

4.3 Outcomes of the Use of Analogies

Student understanding in the mole concept for the three classroom cohorts (143 students, in the 2005 academic year) after implementing the analogies were captured by the *stoichiometry concept questionnaire (SCQ)* (see Dahsah & Coll, 2008), and compared with the research findings from previous work (97 students, in the 2003 academic year) (Dahsah & Coll, 2008) which was similar in context (i.e., teacher experience, class and school size), but taught by traditional teaching.

Table 1. Comparison of student understand of the mole concept for students learning by traditional teaching and learning with analogies

Mole Concept	Proportion of students hold sound understanding (%) after learning via	
	Traditional	Analogies
1. number of entities	33	66
2. molar mass	37	57
3. molar volume	18	44

The findings suggest that there is no concept that more than half of students who learned via traditional teaching hold sound understanding. Of particular note, is the concept of molar volume, for which only 18% students held a sound understanding. In contrast, of students who learned using the analogies described above, more showed sound understanding – although this was not perfect either. For example, for molar volume, less than half of the students taught using analogies showed sound understanding, and many students still thought that one mole of all substances had a volume 22.4 dm^3.

4.4 Conclusions and Implications

Analogy seems an effective technique to teach the mole concept. It can promote students' understanding of unfamiliar concepts and helps them to make connections between unfamiliar science concepts by linking them with familiar ideas and experiences. The literature reports learning benefits arising from the use of analogy when teaching science. However, the effective use of analogy is not simple (Coll, France & Taylor, 2005). We need to map the like and unlike attributes of the analogy and target science concept, and identify differences between the analogy and target (Harrison & Coll, 2008). Chiu and Lin (2002) suggest that teaching using multiple analogies is better than using a single analogy.

5 Teaching chemical kinetics using inquiry-based practical classes

Chemical kinetics is the branch of chemistry which addresses the question how fast reactions go. In many chemical reactions, the rate of a reaction changes while the reaction progresses. Initially, the rate of a reaction is large, and as the reaction progresses the rate of a reaction becomes to decrease, eventually to zero when the reaction is complete. Interestingly, almost all everyday processes involve chemical kinetics in some way. For example, acid rain is a problem in many large cities worldwide, including Bangkok, Thailand. Acid rain is mainly caused by emission of sulfur dioxide (SO_2) and similar species from motor vehicle exhausts, and this has become a serious environmental problem in many large cities. It can severely damage buildings in a city, and it is obviously of interest to scientists and citizens alike to know how quickly such destructive reactions might take: this is the sort of information we can get from the study of kinetics.

Like other topics, chemical kinetics is often difficult for many students to comprehend. Justi and Gilbert (2003) observe that there is a paucity of research about the teaching and learning of chemical kinetics at any level. In general, the teaching and learning of physical chemistry including chemical kinetics is teacher-dominated in approach at both the secondary school and tertiary levels. Many science teachers typically emphasize the qualitative aspects to aid understanding of the influence of variables such as temperature, concentration, and surface area on the rate of a chemical reaction.

Much teaching of chemical kinetics involves the use of chemical experiments or other laboratory/practical activities. There are several reports in the literature describing the experiments or equipment, which have been used in teaching and demonstrating the concept of kinetics. For example, Parkash and Kumar (1999) reported on experiments about chemical kinetics involving gaseous carbon dioxide formed from the reaction between ethanoic acid and sodium hydrogen carbonate at different time intervals. Likewise, Choi and Wong (2004) demonstrated the experiments about the first-order kinetics involving the application of a datalogger (a computer interfaced to one or more sensors).

However, such experiments are very expensive to set up, so are not always suitable for educational contexts for which there is limited access to sophisticated electronic instruments.

Laboratory activities are seen as a means of allowing students having a variety of multisensory experiences, engaging them with experiences of concepts, and at the same time developing their practical science abilities and skills (Lazarowitz & Tamir, 1994). Despite their potential, science practical activities including chemistry at both the school and higher educational levels generally follow a cookbook style in which students are presented with aims and detailed steps for carrying out the experiments. In which case students may or may not learn something about the way scientists do things in the circumstances. It is argued in the literature that this teaching approach is not only an ineffective means of developing students' understanding of science concepts, but also presents a misleading way of how scientists develop scientific knowledge and skills (Lazarowitz & Tamir, 1994). Many research studies have been conducted to investigate the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals. For practical work at both the school and high education levels to be real value, the literature suggests it needs to involve an inquiry-based approach to chemistry learning (Bybee, 2000; Hofstein & Lunetta, 2004; Lunetta, 1998; Nahkleh et al., 2004).

In the context of the science laboratory, inquiry includes the following components: asking relevant questions, hypothesizing, choosing a research question for further investigation, planning an experiment, conducting the experiment, and finally analyzing the findings and arriving at conclusions. If engaged in inquiry-based learning in the laboratory, students can come to understand the nature of scientific inquiry by engaging in inquiry themselves. However, students' knowledge about scientific inquiry and the nature of science does not occur automatically once they are placed in a laboratory. Students do not develop an understanding simply through experiment inquiry; instead they need to learn from their experiences in the laboratory under expert guidance (Hume & Coll, 2008). Hence, chemistry teachers need to provide students with experiences in methods of scientific inquiry and

reasoning, and in the application of scientific knowledge related to everyday life (NRC, 2000).

5.1 Teaching Chemical Kinetics in Thailand

Most chemistry practical classes in Thai schools and universities are traditional in approach, meaning they are teacher-dominated, and that practical classes often follow a cookbook style, or consist of teacher demonstrations of practical work in laboratory sessions. In Thailand the national curriculum states that at any level of education, teaching–learning activities must emphasize 'learning to think, to do and to solve problems' (Pravalpruk, 1999). Several studies suggested that while laboratory investigations offer excellent settings in which students can make sense of phenomena and in which teachers can better understand their students' thinking, laboratory inquiry alone is *not* sufficient to enable students to construct the complex conceptual understandings of the contemporary scientific community (Bybee, 2000; Hofstein & Lunetta, 2004; Lunetta, 1998;). The main goal of our recent research described here, is to demonstrate how providing students with opportunities to be involved in inquiry-type activities in the chemistry laboratory enhanced their attitude to and interest in chemistry laboratory, and improve their perceptions of chemical kinetics in Thailand.

5.2 Innovative Pedagogy to Teaching Chemical Kinetics in Thailand

Recent research was conducted in Thailand to improve the teaching of kinetics via inquiry-based learning in the laboratory (Chairam, Somsook & Coll, 2009). A key feature of this work was that active teaching and learning must involve students doing practical or laboratory work themselves, rather than just watching the teacher conduct a demonstration in the laboratory or classroom.

An example of a methodology that includes experience and associated learning in its design is inquiry-based learning in which:

1. Learning is driven by the need to solve a problem or make sense of a situation;

2. A problem is presented along with the information and tools to solve it;
3. Learners are required to draw on past experience; and
4. Learners need engage in new experiences, such as a problem-based learning or research.

The experiment developed focuses on the kinetics of acid-base reactions. Acids such as hydrochloric acid (HCl) react quickly with calcium carbonate ($CaCO_3$) to product a salt and water, and releases gaseous carbon dioxide. Other acids such as the acids present in vinegar also react with carbonates.
The reaction is:

$$CaCO_3\ (s) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + H_2O\ (l) + CO_2\ (g)$$
(egg shells)

In the reaction above, how the acid and carbonate react depends on a number of factors, including the concentration of the acid, the particle size of the carbonate, and the temperature of a reaction. The chemical equation can be applied to determine the rate of a reaction by plotting the carbon dioxide generated over time. The experiment is first-order in its kinetics with respect to calcium carbonate and acid. The experimental data from kinetics investigations can be analyzed using standard computer software (i.e., Solver Parameters in Microsoft Excel).

The rate law for any given chemical reaction is the mathematical equation which describes the progress of that reaction. It is important to realize that we cannot infer the rate of any reaction from the equation. In particular, the stoichiometric coefficients only tell us about the ratio with which reactants combine to produce products. The rate and rate law (i.e., how the rate depends on the concentrations of any of the species) for any reaction must be determined from experiments. What we want students to do is experiment with different species and reaction conditions to see how the rate of this reaction varies depending on reaction conditions. The experiment used in this work was devised to be more open in nature, so that the students would do things in a way more like scientists. The students were required to conduct an experiment in which they try to examine the aspects of chemical kinetics for the acid-base reaction between eggshells (mostly calcium carbonate)

and acids (hydrochloric acid and vinegar). That is, the students had to design the experiment procedure themselves to gain an understanding of the process of scientific inquiry.
In laboratory activities, students were required to design the experiment for studying how variables affect the rate of a reaction. The variables are:

1. Surface of solid reactant, calcium carbonate to egg shells;
2. Concentration of hydrochloric acid or vinegar;
3. Temperature of the reaction; and
4. Type of acid used in the reaction.

The students are involved in more 'open-ended-type' activities. It is intended that this approach allows the students to construct their knowledge by actually conducting authentic scientific work. This includes the following:

1. Asking relevant problems concerning the phenomena that students have observed;
2. Formulating a hypothesis that is in alignment with the suggested problems;
3. Choosing an appropriate problem for further investigation;
4. Conducting a suitable experiment in order to investigate this problem (including prediction, observations, and explanation);
5. Analyzing the findings and arriving at conclusions; and
6. Sharing the ideas between their classmates.

The Prediction-Observation-Explanation (POE) technique - a learner-centered strategy that arouses students' curiosity (White & Gunstone, 1992) was incorporated into the experiment. The questions focused on four POE activities looking at the influence of variables on chemical kinetics: surface area, temperature, concentration and type of acid on the rate of a chemical reaction. In a whole-class setting, the students were asked to predict the results of some events and justify the reasons used to support their prediction. Students then were asked to describe what they observed when a reaction occurs while doing the experiment. Lastly, they were required to explain any conflict between what they have predicted and observed. Typically in this chemistry laboratory, the students performed the experiments in small mixed gender groups (4–5).

5.3 Student Understanding of Chemical Kinetics via Inquiry-type Laboratory

The students in groups had to form hypotheses that could be tested by collecting data, conduct scientific experiments that control all but one variable, predict the outcome of the results, collect and record data accurately, and finally explain and interpret their data. Examination of the findings suggested that many students were able to provide good experimental design which could test their hypotheses (see Figure 1).

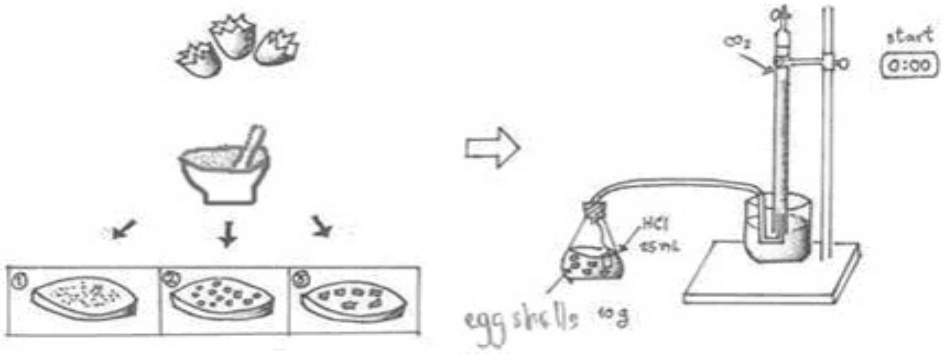


Figure 2. Students' experimental design for the preparation of egg shells and the collection of carbon dioxide (CO_2)

The experimental procedure presented here was clear and simple, and the students identified three groups of variables (i.e., independent variable, dependent variable and controlled variable) for investigation in the experiment. The following example illustrates a typical approach:

> Problem: Influence of surface of egg shells to the rate of a reaction
> Hypothesis: The different surface of egg shells gives a different rate of a reaction
> Independent variable: Influence of surface of egg shells
> Dependent variable: The rate of a reaction
> Controlled variable: Size of Erlenmeyer flask, type of acid used, concentration of acid, reaction temperature, source of egg shells, laboratory environment, etc.

The sample preparation in this experiment involved a sample of egg shells and is seen here an essential stage, since it is a key step to successful completion of the experiment. There is no single method of sample preparation for the solid reactant (egg shells), meaning students had to decide how to prepare the solid sample themselves; like real scientists. They felt the particle size of egg shells should be consistent, and thus they ground the shells in mortar to obtain a fine powder with uniform (homogeneous) particle size:

> Sample preparation of egg shells: In this part, the particle sizes of the solid reactant should be made at least into three sizes: big, medium and small (like sands) size. The white layer which covers on the egg shells should be removed before grinding.

The formula $C_1V_1 = C_2V_2$ was generally used to calculate the acquired concentration of hydrochloric acid or vinegar. The students were required to design their own experimental procedure after they decided the how to investigate the problem:

> Weigh egg shells 0.1 g and then pour them into the flask… Pour HCl (aq) 4.0 mL into the vial and then place it into the Erlenmeyer flask (be careful not do not mix HCl with egg shells)…fill the water into the 25.0 mL burette…Connect the burette and the flask with the U-tube and the rubber stopper…Shake gently the flask, mixing HCl and egg shells together …Observe the volume of CO_2 in the burette and record the results at time…Change the type of acid used from HCl to vinegar and then repeat the experimental procedure.

In general, the students could carry out the experiment to investigate the influence of surface of egg shells. Students in each group have to vary the particle size of egg shells themselves, and to explain the influence of surface area of the solid reactant and the rate of reaction, the students commonly reasoned that the change of the rate of a reaction is due to changes in physical dimensions of the solid reactant. After completing the experiment, in whole class discussion, the experimental data from investigations of kinetics are analyzed by the class to compare the rates of reaction by plotting the relationships between the amounts of carbon dioxide over time. The students concluded that:

> The rate of a reaction is dependent on the surface of the solid reactant (egg shells). If the size of egg shells is big, the rate of a reaction is slow. On the other hand, if the size of egg shells is small, the rate of a reaction is fast.

Some students drew upon analogy of a cube to explain the increase of the surface area of solid reactants. This was perhaps because it was simple for students to understand in their mind as is important feature of the student-generated analogy (Coll, France & Taylor, 2005):

> If we put four cubes together, the surface area is only 16 cm^2. However, if we separate all four cubes away from each other, the surface area is 24 cm^2.

To investigate the influence of concentrations, the students generally started carrying out the reaction from low to higher concentrations. Most students said "the effect of concentration of acid used was due to the number of particles in the solution". To investigate the influence of temperature, most students start doing a reaction at low temperature and then moved on to higher temperatures, although some start at higher temperatures and moved to lower temperatures. Students observed that the rate of a reaction increases at higher temperatures:

> When increasing the temperature for a reaction, the kinetic energy of reactant molecules increases. So, molecules move faster and more collision. The rate of a reaction increases and then the reaction occurs quickly.

To explain changes in the rate of a reaction as a result of the different acid used, most students explained it in terms of the 'strength' of the acids; again in accordance with the scientific view:

> The rate of a reaction increases when using the strong acid [i.e. HCl]. On the other hand, the rate of a reaction decreases when using the weak acid. HCl is more active than vinegar. Hydrochloric, a strong acid, dissociates more completely when it dissolves in water and it is a good H^+ donor. On the other hand, vinegar, a weak acid, dissociates only slightly when it dissolves in water and it is also a poor H^+ donor.

Most students had a better understanding of chemical kinetics, were able to explain the changes in the rate of a chemical reaction, and also developed a better conceptual understanding of chemical kinetics. Typically, they explained their findings in the following way: "At the beginning, the slope of graphs is very sharp, because the rate of a reaction is large. As the reaction progresses, the reaction becomes slower. The rate of a reaction decreases, eventually to zero when the reaction is completed".

5.4 Conclusions and Implications

The new experiment here was conducted in order to allow Thai science students to develop student-centred learning processes based on inquiry-based learning. They had to design the experimental procedure themselves, and this seemed to help them gain a better understanding of the process of scientific inquiry. This is in marked contrast to the 'normal' situation for teaching chemical kinetics in Thailand, which more often simply involves following laboratory instruction or watching teacher demonstrations. The use of small group discussions also seems to reinforce the socially negotiated nature of scientific knowledge; more consistent with more holistic views of the nature of science and genuine inquiry-based learning (Hume & Coll, 2008).

A key feature needed to move students from passive to active learning was the use of the POE strategy, along with small group discussions. Most students were able to explain changes to the rate of a chemical reaction based on kinetic theory, and drew upon energy and particle theory to explain changes in rates of reaction. They understood how to conduct experiments, and the notion of investigating variables by changing each separately, while maintaining the others constant. They also had a better understanding of chemical kinetics, were able to explain the changes in the rate of a chemical reaction, and also developed a better conceptual understanding of chemical kinetics. One intention of this new type of experiment was to relate the laboratory classes to daily life, since the chemicals used in the experiments were, sometimes, not purchased from a chemical company. This also introduced an element of student choice, with respect to research design and the conduct of the experiment.

6 Summary and conclusions

All three of these studies sought to help student learn chemistry better and to enjoy their leaning but fostering an active-learning environment. The driving force behind the interventions was a desire to develop learner-centred instruction that is consistent with the aims of the Thai science curriculum. As such the interventions consisted on hands on activities, such as laboratory work, collaborative group learning, argumentation and analogy. Specific pedagogies included POE, IBL, IAE/IAI, and Jigsaw IV. These are plainly more active pedagogies than is common in most Thai classrooms or laboratories (at any level of schooling), and the research findings point to some gains in terms of learning. There is reasonable evidence that learning outcomes were enhanced. Given that such pedagogies are not common and thus represent a new experience for Thai learners, it is not surprising the interventions need some further work; this is subject to on-going research in our research group. It also is not surprising that in some cases students were initially uneasy about these approaches. Deviation from normal practice can be alarming for students, especially high-achieving students who have learnt how to succeed in a traditional, teacher-dominated, highly structured classroom environment. Likewise, teachers must cede some control of the classroom, and may worry that they will be able to complete the curriculum. It is positive that as the teachers became accustomed to leaner-centred, more active learning, they became more confident and at ease with these new approaches. This along, with the benefits in terms of learning outcomes, is encouraging. Thailand has committed to more innovative pedagogies, and a learner-centred teaching approach. These studies indicate that this is possible but that it will take some time for all stakeholders to become comfortable with this. We add one final qualifier; at some point Thai authorities will need to consider the match between the desire for more active learning in the classroom or laboratory, and the nature of the assessment regime. As Coll and Taylor (2008) observe, assessment drives teacher and student behaviour and if there is miss-match between the assessment processes and pedagogies, the assessment regime wins every time.

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Acquiring and assessing structural representations of students' knowledge

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SUMMARY

Parents, politicians, and teachers consider schools a place where students are supposed to learn. If our aim as teachers is to be professional in the real sense of the word, we need to be prepared to learn how to innovate and improve our teaching. In this chapter, two useful tools for improving the quality of our teaching are considered. One tool is the concept map, an increasingly popular tool for helping students represent their knowledge by making explicit how they relate key concepts in a knowledge domain. Another is the word association test, a useful and quick tool for assessing the relationships, in the mind of our students, between concepts of the syllabus. The use and the problems connected with these tools are presented and evaluated.

KEY WORDS: Structural knowledge, Meaningful learning, Concept maps, Semantic distance, Word association test, Relatedness coefficient.

1 Introduction

The hallmarks of expertise are possession of skills and understanding resulting from the accumulation of a large body of knowledge. The accumulation of this knowledge enables experts to easily find and retrieve bits of knowledge from long-term memory. This implies that the expert's representation of knowledge, that is, how the knowledge is organized and structured in the mind, is formed in such a way as to make the structure effective and efficient.

As instructors in general, and chemistry teachers in particular, we know the difficulties, the perplexing problems and questions that we confront in order to improve the knowledge of our students in our subject. We need to begin where our students are: without attachments and anchors in long-term memory, a student can only learn by rote methods. (Johnstone 2010, p. 25) Knowledge that is not subsumed is either rejected or is rote learned. (Johnstone and Moynihan, 1985) The task is demanding and challenging because we need to end where the expert is; learners need to have a cohesive and highly integrated knowledge structure. By a "structure" we mean an assemblage of identifiable elements and the relationships between those elements (Shavelson, 1972). "Cognitive structure" is a hypothetical construct referring to the organization (relationships) of concepts in memory (Shavelson, 1974).

Educational researchers and all chemical educators need to acknowledge the improvements that the studies about how people learn and the wisdom of practice can offer in raising the quality of our students' knowledge standard. Maybe it is true that we learn to teach by doing, but it is not wise and not fair toward our students if every new generation of teachers has to start from scratch to learn to teach in a professional and effective way. As experts involved in educational research, we have to offer techniques and advice, because our colleagues ask for responses to a series of demanding questions in order to improve their teaching. (Zare, 2008)

Human cognition organizes and structures knowledge in different complexity levels: higher-level knowledge is formed by first acquiring simpler concepts, which are then used to learn and understand complex ones. The central problem of instruction is how to structure and present a body of knowledge to learners so that the communication of this knowledge to the learner can be effective and his learning correspondingly efficient. (Shavelson, 1972, p. 225)

In the effort to understand the functioning of our 'black box', cognitive scientists distinguish between declarative knowledge and procedural knowledge. (Anderson, 1995, p. 234-235) Declarative knowledge is explicit knowledge of some object, event, definition, or idea and of which we are consciously aware. "Knowing that" is synonymous of declarative knowledge. Much declarative knowledge consists of

propositions that describe the properties of an object or substance or describe the relations between concepts. Examples are "metals are good conductors of heat and electricity," "PV = nRT," "the chemical formula for ammonia is NH_3."

Procedural knowledge is synonymous of "knowing how". Procedural knowledge involves knowing how to do something; it is knowledge of a sequence of operations that can be applied to a class of tasks. Examples of procedural knowledge are knowing how to balance a chemical equation, knowing how to separate the products of a reaction by a chromatographic column, or knowing how to solve a problem.

Jonassen et al. proposed and argued the existence of an intermediate type of knowledge: structural knowledge. Structural knowledge mediates the translation of declarative into procedural knowledge and facilitates the application of procedural knowledge. (Jonassen, Beissner and Yacci, 1993, p. 4) Structural knowledge describes how the declarative knowledge is interconnected. Shavelson calls this type of knowledge *schematic* knowledge – "knowing why". For example, schematic knowledge involves knowing why the first ionisation potential of oxygen is lower that that of nitrogen.

As teachers, we want our students to develop knowledge of when, where and how their knowledge applies: this type of knowledge is called *strategic* knowledge. (de Jong and Fergusson-Hessler, 1996; Shavelson, Ruiz-Primo and Wiley, 2005) Beyond being made up of different types, knowledge is characterized by several qualities. (de Jong and Fergusson-Hessler, 1996)

The representation of knowledge is one of the most important topics of cognitive psychology. According to cognitive psychology, knowledge is the storage and organization of information in memory. For the sake of simplicity, we can conceive of the memory system as including (a) sensory input from the physical world into (b) working memory which interacts with (c) long-term memory to store information and use that information toward some goal (e.g., problem solving, decision making), that results in some (d) response in the external world.

For better understanding of what follows, we can imagine long term memory as a semantic network of interrelated concepts. According to this model, every concept (node of the network) is represented in relations to other concepts, or propositions. "If memory is organized as a semantic network, then learning can be conceived as a reorganization of the networks in semantic memory." (Jonassen, Beissner and Yacci, 1993, p. 7)

Substantive structures are networks of meaning composed by concepts and systematic relationships among those concepts. (Finley and Stewart 1982, p. 595) Without a well-developed and interconnected cognitive structure, it will be difficult for students to apply their knowledge, to extend their thinking or to remember the material because they have never fundamentally understood the concepts and the relationships between them.

As a consequence, every tool that helps to represent and organize the knowledge can be potentially useful in the classroom, with the purposes of (a) assisting our students and facilitating them in the task of acquiring new knowledge, and (b) informing us about the gap between where we would like our students to be and where they are so we can provide feedback to close the gap.

In this chapter, two tools for representing students' knowledge structures will be considered: Concept Maps (CM) and Word Association Test (WAT). Concept maps are considered a viable instructional tool for promoting meaningful learning, while WAT can be used for diagnostic purposes; both can be used as formative assessment tools for closing knowledge gaps.

A concept map is a graph consisting of nodes representing concepts and labelled lines denoting relationships between the concepts. (Ruiz-Primo and Shavelson, 1996, p. 569)

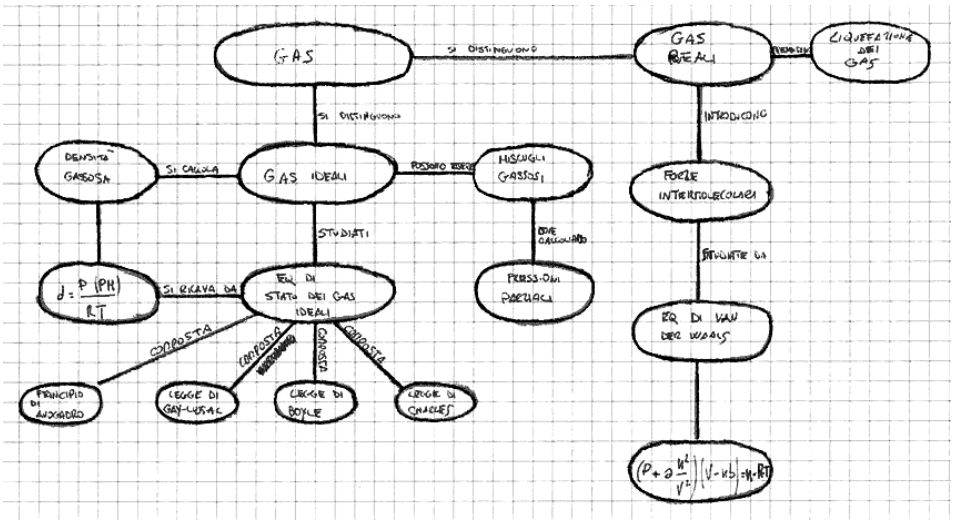


Figure 1. Example of a concept map with the title "Gas".

Concept maps are a useful tool for helping students to reflect on what they are learning by using verbal representation, symbols, images, and graphics. From a teacher's point of view, they show what goes on inside the 'black box'; concept maps can be a window into a student's thinking at a certain point of her or his education. Concept maps were invented in 1972 by Joseph Novak in the context of a research work as a graphical representation of knowledge. (Novak and Gowin, 1984; Novak and Musonda, 1991; Cardellini, 2004; Novak, 2005, p. 29) They can be used in virtually all schooling subjects (Stoddart, Abrams, Gasper and Canaday, 2000) and their use is becoming increasingly popular.

2 Concept Map Methods

Concept maps provide a representation of the structural relationships students construct between important concepts within a knowledge domain. Concept maps are a part of an active learning method because they ask students to be involved in the construction of meaning and increase their learning opportunities. (Novak, 1993; Novak and Gowin, 1984; Novak and Cardellini, 2004) Following Novak and Gowin (1984), a concept map might be presented to students as a hierarchical representation consisting of concepts linked with arrows pointing in

explicit directions to convey meaning between concepts. (Novak and Gowin, 1984) However, according to Ruiz-Primo and Shavelson (1996, p. 578), "Methodologically and conceptually, there is no need to impose a hierarchical structure." The concepts linked with labelled lines, called propositions, depict some aspect of personal knowledge. "Concept maps should be hierarchical; that is, the more general, more inclusive concepts should be at the top of the map, with progressively more specific, less inclusive concepts arranged below them." (Novak and Gowing, 1984, p. 15-16) They can be constructed with various tools, including paper and pencil and computers. CMap software for building concept maps is available free for non-profit use at http://cmap.ihmc.us/ (accessed January15, 2010).

In a concept map the concepts are listed only once, but there can be multiple links between the concepts. "Propositions reflect the extent of differentiation of concepts. That is, the more concepts to which a given concept is linked (more propositions formed with the concept), the better defined or explicated that concept is." (Jonassen et al. 1997, p. 290) The labelled lines (links) can connect concepts at the same or at a different hierarchical level. If the links connect concepts at a different hierarchical level, the propositions are called crosslinks.

3 Concept Map Research Findings

The literature on applications of Concept maps in science, technology, engineering, and mathematics is quite extensive, and a comprehensive review of it is well beyond the scope of this chapter. They are used in education as well as in business. (Novak, 2010) In literature there are many examples of the use of concept maps in many chemistry subjects (Ring and Novak, 1971; Matthews and Brooks, 1984; Novak, 1984; Novak, 1990; Stensvold and Wilson, 1990a; Stensvold and Wilson, 1990b; Ross and Munby, 1991; Ebenezer, 1992. Adamczyk, Willson and William, 1994; Fellows, 1994; Nakhleh and Krajcik, 1994; Pendley, Bretz and Novak, 1994; Wilson, 1994; Botton, 1995; Regis, Albertazzi and Roletto, 1996; Liu and Hinchey, 1996; Markow and Lonning, 1998; Brandt et al., 2001; del Pozo, 2001; Nicoll, Francisco and Nakhleh, 2001a; Nicoll, Francisco and Nakhleh, 2001b).

A meta-analysis conducted on 19 studies on the effectiveness of concept mapping as an instructional tool shows that CM generally has positive effects on both student achievement and attitudes. Concept mapping helps to raise individual student achievement in the average study by a 0.46 standard deviation. However, the positive effects depend on the subject area under examination. (Horton et al., 1993)

Generally, the studies found instructional benefits in the use of concept maps, although in few there is no significant difference between the students who did and did not construct concept maps while learning conceptual chemistry (Stensvold and Wilson, 1990a; Markow and Lonning, 1998).

4 Instructional Use of Concept Maps

In the very first lesson, students are summarily instructed on how to draw a concept map. I give my students handouts about how to draw a concept map, according to the criteria developed by Novak and Gowin (1984). With drawing of concept maps, five aspects must continuously be taken into account: the hierarchy of concepts, the links between them, the branching of concepts, the cross-linking, and the examples. In the handouts, several examples drawn by students in previous academic years are also provided. After having drawn a map, I suggest that students verify the cognitive consistency of the reported concepts, running backwards through the branches, from the examples to the main concept (the title of the map). In order to learn meaningfully the students are told that it is important to be sure the linking propositions between the concepts or their absence are justifiable. When in doubt, students are advised to study the material of the lecture again, focusing their attention on the concept (or concepts) not completely understood.

Students are encouraged to use the maps for three related purposes: to make their own mental network explicit, to check their knowledge as it grows, and to have a meaningful summary to go over in preparation for the written and oral examination. After a lecture about a certain topic students are requested to draw a concept map. Every new lesson students are requested to hand in the concept maps to externalize their mental networks. The teacher will look at each of them and in the

following lesson the maps are returned to the owners, sometimes with advice on how to improve them. When appropriate, some suggestions and question marks (using a pencil) are made if wrong linking words or wrong concepts are formed. Students can use the maps during the written and oral exams. After the exam, almost all the students leave the maps with the teacher and over the years I have collected about 15,000 of them.

5 Advantages and Disadvantages of Concept Maps'

There are advantages and disadvantages of the use of concept maps. One of the disadvantages is the time-consuming process of drawing a good map (Jonassen, Beissner and Yacci, 1993, p. 162). This explains why some students do not like them. Furthermore, verbal and spatial abilities (Hilbert & Renkl, 2008) play a role in the number of concepts reported. My students are free to choose to draw concept maps or not. Some do not draw them, including several students that are global learners, according to the Index of Learning Style. (Soloman and Felder, 1988). The large majority of my students draw concept maps. Even if it is time consuming to draw a concept map, the majority of my students consider concept maps an useful tool because they can "serve… as a kind of *template* or *scaffold* to help to organize knowledge and to structure … [their knowledge]" (Novak & Cañas, 2008, p. 7).

From the data collected in many years of using concept maps in chemistry education it is safe to assert that: 1. maps are idiosyncratically constructed by each student; 2. use of the maps makes the study of chemistry more meaningful. Sometimes, the maps are corrected by the students themselves and improved over time, as their knowledge and awareness increase.

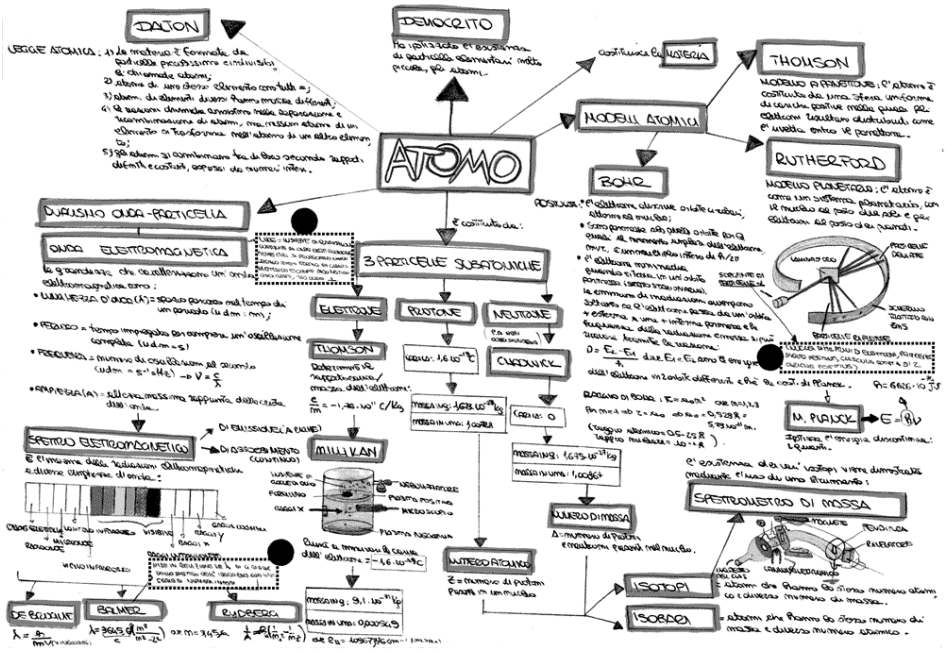


Figure 2. The three concepts and explanations emphasized have been added later in pencil.

The maps are constructed idiosyncratically by the students, possibly according to their learning styles and/or the time and the effort they choose to invest in this learning tool. The 'styles' of the maps are quite different and some maps cannot be included in this category, according to the Novak and Gowin (1984) criterion, because some of the requisites in the maps are missing. But still, even these concept maps can be useful for the students that have made them.

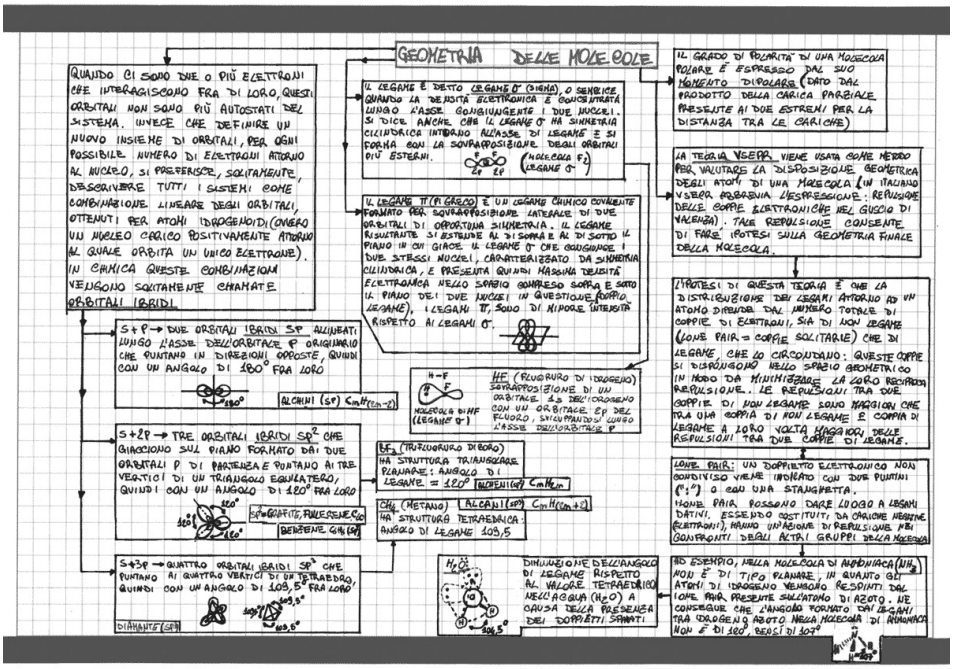


Figure 3. In this map the concepts are explained, but the hierarchy between the concepts has not been established.

The analysis will be restricted to the maps of 17 students that passed the final exam immediately after the end of the last general chemistry course. The quality and the number of maps (from 0 to 68 maps, mean value 24.1 and standard deviation 20.4) and the concepts reported on them vary in a significant way, as reported in table 3.

6 The Word Association Test

Everyone who has taught science finds it difficult to believe that information and understanding cannot be transferred intact from the head of the teacher into the head of the student. Probably every science instructor has experienced the disappointment of seeing, in examination papers and in oral examinations, the misunderstandings exhibited by students. A more realistic view is that every student reconstructs knowledge and understanding from the information the teacher

presents and from the textbooks, in the light of the knowledge and understanding the student already has. Research shows that students can hold simultaneously the teacher's ideas and their own ideas even though they may be in conflict. (Pellegrino, Chudowsky and Glaser, 2001, p. 84) Under pressure, students tend to revert to their own ideas. A technique which would enable the teacher to probe the effectiveness of teaching and to "look inside the student's head" to discover where the misconceptions are, is the Word Association Test.

The Word Association Test assumes a network model firstly proposed by Collins and Quillian (1969) as a model of semantic memory. This model was based on the assumption that memory could be presented by a semantic network arranged into a hierarchical structure. In the model the nodes were arranged in superordinate-subordinate relationships (Collins and Quillian, 1969) "Hierarchical structure may be appropriate for some domains, but not all." (Goldsmith and Johnson, 1990, p. 243; Ruiz-Primo & Shavelson, 1996)

In the mind there are "a very large number of concepts, and concepts must have very complicated structures. A concept can be represented as a node in the network, with properties of the concept represented as labeled relational links from the node to other concept nodes. These links are pointers, and usually go in both directions between the concepts." (Collins and Loftus, 1975, p. 408)

According to recent views, knowledge is represented in long-term memory as a network, or web, in network models of memory, and memory processes are defined within the network. In most such models the networks are hypothesised to consist of nodes which are cognitive units (either concepts or schemata) and links, the relations between these cognitive units. Concepts, schemata, and ideas are represented by the nodes within the nets that Reisberg sees as just like the knots within a fisherman's net. The nodes are connected to each other by links called associations. (Reisberg, 1997, p. 258) Activation spreads from one node to another on the network as one searches through the network, and it takes time to traverse the levels in the hierarchy. Search through the network is like a travel and if one must travel further, it should take longer to reach the destination. (Warren, 1977) "The length of a path may be thought of as an inverse measure of the strength of the relation

depicted by the path." (Rips, Shoben and Smith, 1973, p. 17) The processing time could be determined by two factors. "One is the time for activation to spread through the network. The other is the time for production of conditions to match. ... the critical factor is the time for conditions to match and we can regard the spreading process as instantaneous." (Anderson and Pirolli, 1984, p. 794)

The underlying assumption in a word association test is that the order of responses reflects at least a significant part of the structure within long-term memory and between concepts (Shavelson, 1972). The importance of the relationship between concepts in the mind has been stressed by several scholars. According to Preece, "word meanings, or concepts, are like mathematical points: They have few qualities other than their relationships with other concepts." (Preece, 1976, p. 1) This is because "a concept is never isolated in our memory, but embedded in a network of associations which colour the concept with sensory attributes, emotions, and with other concepts." (Schaefer, 1979, p. 89) And the "Relations between concepts are as important as the concepts themselves because they provide much of the context in which each concept acquires a specific meaning" (de Vos, van Berkel and Verdonk, 1994, p. 743)

Let u and v be two different stimulus words. For a given individual let the associative meaning of u be $A = (a_1, a_2, ..., a_n)$, with $a_1 = u$ and $a_2, ..., a_n$ words associated to u. In a similar way, the associative meaning of v as $B = (b_1, b_2, ..., b_m)$, with $b_1 = v$ and $b_2, ..., b_m$ words associated to v. The relationship between two different words u and v is a function of the degree to which their respective response distributions (hence meaning) overlaps. If $a_2 = b_2$, $a_3 = b_3$, etc., we can assume that u and v are very closely associated because they have the same meaning. "Complete identity in associative meaning can occur *only* if two stimulus words *always* elicit each other and *no other* words." (Deese, 1962, p. 167) On the other hand, if the responses to u and v share no commonality, then A and B would be deemed to be unrelated. The numerical strength of these associations can be calculated to obtain a semi-quantitative measure of association. (White and Gunstone, 1992, ch. 9; Cardellini, 2008)

A relative index of the overlaps between pairs of primers can be obtained using Garskof and Houston's formula (Garskof and Houston, 1963). The Relatedness Coefficient (RC) obtained using Garskof and

Houston's formula can range from 0 (totally unrelated) to 1 (perfect relatedness; the same word) and measures the number of identical words given as responses to two key words and their rank order in the response distributions. In a word association test, the degree of overlap between the response hierarchies is a measure of the semantic distance between the primers, or the "strength" of links between concepts, in memory (Deese, 1962; Rips, Shoben and Smith, 1973).

7 Method

In the present study a word association test was used to map the cognitive structures of first-year engineering university students in a course of general chemistry at the Università Politecnica delle Marche. About 35 students attended the lectures regularly, and a total of 43 students finished the course (age 19.9, standard deviation 1.3, between 18 to 26 years; 28 boys and 15 girls). 28 completed the Motivated Strategies for Learning Questionnaire (MSLQ, Pintrich and DeGroot, 1990; Pintrich et al., 1993): the scores ranged from 160 to 253 (out of 280), mean value of 210.5 and a standard deviation of 25.0. In the 50 hours of the course more than 5,000 problem solutions were collected and corrected; on average, 122.0 individual problems, ranging from 30 to 433, with a standard deviation of 83.7. Some students solved difficult problems in an original and creative way. (Cardellini, 2006)

To construct the word association test, ten key words (primers) from the domain of General Chemistry were chosen to act as stimuli. These words were selected because they were related to key information and concepts on which the course was based. The words were *Reaction* (1), *Equilibrium* (2), *Chemical bond* (3), *Molecular shape* (4), *pH* (5), *Oxidation-reduction* (6), *Energy of reaction* (7), *Solution* (8), *Acids and bases* (9), *Atom* (10).
For purposes of example here, I focus on the WAT that the 45 students completed during the last lesson of the course. In a booklet distributed to every student the first page contained the following instructions:

> When you hear or see a word, it often leads you to recall other words. In this study we would like to find out what other words are brought to your mind by some words used in chemistry. On each

page you will find a key word written many times. Repeat the word to yourself, and then as quickly as possible write the first word that comes to mind in space number 1. And then continue to write in the other spaces other associated words that come to mind. Continue in this way until you are told to turn to the next page. Try your best. Write as quickly as possible since you are allowed only 40 sec. for each page.

The following two pages provide two examples of word association responses with two primers: *Eagle* and *Force*. The final ten pages constitute the test: they are randomized in every booklet in order to prevent the responses to be influenced by always being preceded by the same stimulus word across students. (Cachapuz, 1987) Each primer was written at the top of the page and ten times down the left side of the page so that subjects were encouraged to return to the stimulus word after each association, in order to minimize the chain effect, in which each response, instead of the key word, becomes the stimulus for the next response (Bahar, Johnstone and Sutcliffe, 1999).

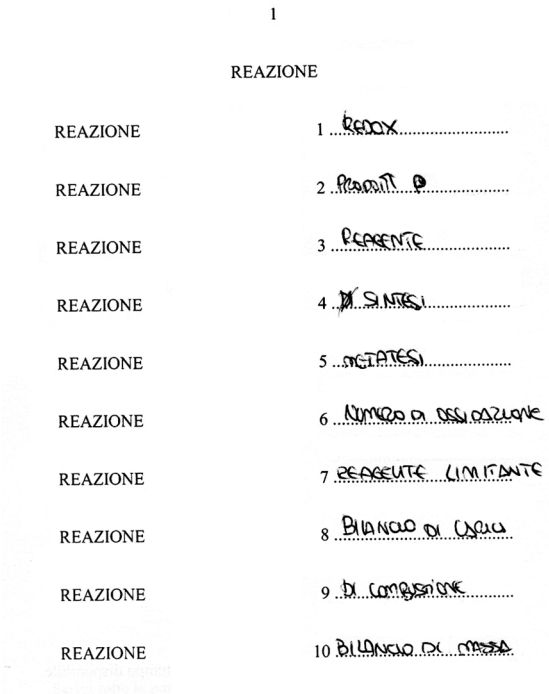


Figure 4. Response sheet for the primer "reaction".

For each stimulus word, students were required to list up to ten words that they considered to be associated with the stimulus word in forty seconds, and the time was controlled by the experimenter. This constraint is because research evidence suggests that a free association cannot reveal weak direct associations (McNamara, 1992). For example, a student response to the primer 'reaction' was the following sequence of associations: 'oxidation-reduction', 'reagents', 'products', 'equilibrium', 'limiting reagent', 'moles of reaction', 'number of moles'.

8 Results and discussion

The responses were analysed and some were rejected. A response is considered 'acceptable' if it is in relation with the stimulus, correct from a scientific point of view, and belonging to the chemical language. Words such as 'shampoo', associated with the word pH, or 'nucleon' associated with the word atom, were rejected according to these criteria. Only one of the two words, 'Oxidation-reduction' and 'redox', may appear in a page, if appropriate; 'oxidant' is considered different from 'oxidation'. The number of associated words generated by students and accepted differs for different primers:

Table 1. Number of associate words for each stimulus word.

Primers		Associated words
1	Reaction	251
2	Equilibrium	194
3	Chemical bond	247
4	Molecular shape	178
5	pH	269
6	Oxidation-reduction	176
7	Energy of reaction	133
8	Solution	258
9	Acids and bases	255
10	Atom	260

For three primers, molecular shape, oxidation-reduction, and energy of reaction, the numbers of associated words are below the average. Three possible explanations come to mind: (1) without information from the

chapter on electrochemistry the students would have difficulty connecting the topic of redox reactions to other concepts, (2) the students did not study or reflect sufficiently on the concepts, or (3) insufficient or inappropriate explanations were given during lectures.

Ten days after the test, 21 students out of 45 sat for and 17 students passed the final exams: the responses of these students where analysed separately. Both, the word association test and concept maps from these students have been used for a study. Counting the number of "accepted" responses to each stimulus word is a method of summarising the word association data. (Shavelson, 1974) The number of different responses to a key word is a significant and direct indication of the understanding of the word, because meaning can be defined as being directly proportional to the number of links the individual can make to the word. The number of their associated words is 954 (13 words were considered inappropriate; 1.4%); The rest of the students found 1247 associated words: here the number of rejected words was 90, 7.2%. The average number of associated words is 56.1 for the students that passed the exam, 48.0 for the rest of the students. It is well known that practice, study and thought given by students reduce recognition and retrieval time. (Pirolli and Anderson, 1985)

It can be predicted that the magnitude of the relatedness coefficient will in general be proportional to the knowledge of the topics. Using the procedure reported elsewhere (Cardellini, 2008), for the 17 successful students' responses, an RC value was calculated between pairs of primers for each student. Table 1 reports the calculated Garskof-Houston RC values for one student.

Table 2. Example of Relatedness Coefficients' for Ss11 (16 overlaps out of 45 possible).

Key words	2	3	4	5	6	7	8	9	10
1	.403	.000	.000	.138	.276	.162	.275	.222	.000
2	-	.207	.000	.000	.000	.000	.158	.173	.000
3	-	-	.118	.000	.000	.063	.000	.000	.158
4	-	-	-	.000	.099	.000	.000	.000	.070
5	-	-	-	-	.000	.000	.408	.254	.000
6	-	-	-	-	-	.000	.000	.000	.000
7	-	-	-	-	-	-	.000	.000	.000
8	-	-	-	-	-	-	-	.000	.000
9	-	-	-	-	-	-	-	-	.000

From the data reported in table 1, there are few relatively strong associations with an RC greater than 0.4 ($RC_{1,2}$ and $RC_{5,8}$) and some good associations with an RC greater than 0.2 ($RC_{1,6}$, $RC_{1,8}$, $RC_{1,9}$, $RC_{2,3}$, and $RC_{5,9}$); six concepts have an association greater than 0.1 and three have an RC below 0.1.

One reason that can explain the low associations is because a severe criterion has been used: the word 'bond' associated with atom has been considered an inappropriate association, even if it may be corrected. If it is a wrong or correct association can only be established by talking with the student. A central concept in chemistry is the equilibrium. In the responses of the 17 students, four response words were discarded as inappropriate, all of them belonging to chemical vocabulary. For the rest of students, 19 words were discarded, five belonging to chemical vocabulary and the others to common language. Strange enough, five students associated 'static' to equilibrium: this is a suspicious misconception because the very nature of the chemical equilibrium is 'dynamic'. But to be sure about the misconceptions, it is necessary to talk with the students.

A similar study was performed some years ago. (Cardellini and Bahar, 2000) From the comparison of this older study with the study presented here, it can be concluded that the strength of the word associations has increased. However, there are still too many concepts unrelated with

other concepts of the curriculum that should be related and at higher levels of association. What emerges from these studies is that students store information in disconnected "islands" whereas teachers tend to have their information stored in highly interconnected networks enabling them to slip easily from one concept to another. This implies the necessity of a different approach to teaching, where the relationships between the concepts are explicitly stressed. This recommendation follows from the importance of a good cognitive structure in problem solving too. (Kempa and Nicholls, 1983)

The matrix of the relatedness coefficients constitutes a representation of the knowledge in a certain domain, and the cognitive structure of a certain student. (Goldsmith, Johnson and Acton, 1991) It is possible to report the data in a visual representation of the interconnection between the key words and the response word, obtaining the corresponding 'map' of concepts.

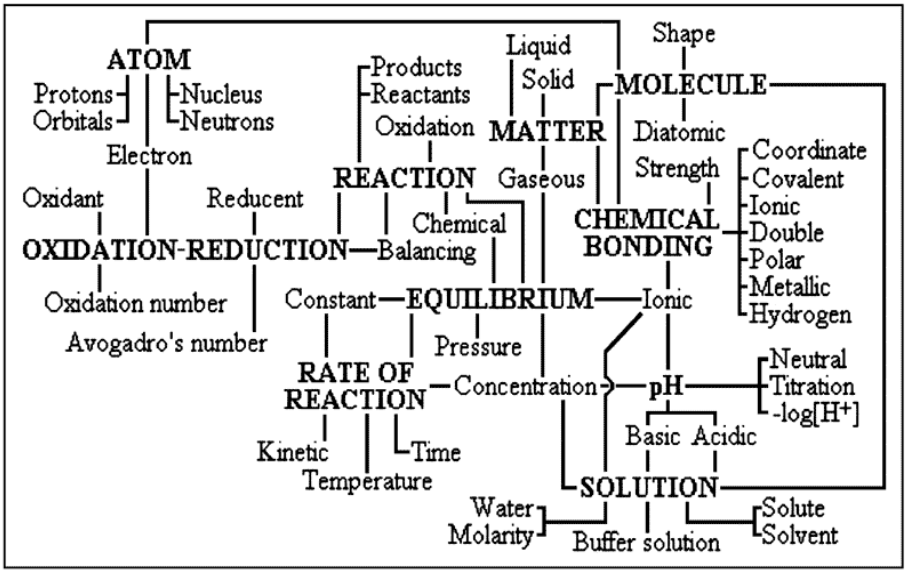


Figure 4. Interconnectedness between key words and the response word in a class of 85 students (mean relatedness coefficient) and the resulting cognitive structure of the best 17 students (Cardellini and Bahar, 2000). This spatial representation has been obtained considering the median values of relatedness coefficients greater than zero.

A multiple correlation was calculated between the score obtained at the final exam and the sum of the relatedness coefficients, the number of overlaps (RC greater than 0), the number of words collected in the WAT and the number of concepts reported in the concept maps. The number of concepts in every map has been searched using the list of the concepts, relative to the general chemistry part of the course. This list of the concepts has been validated by six expert colleagues.

Table 3. Sum of relatedness coefficients, number of overlaps, number of words, and number of concepts for the students that have passed the exam. Only for the number of concepts, Spearman rho is statistically significant at 0.1.

	Sum of RC's	Number of overlaps	Number of words	Number of concepts	Number of cmaps
Ss1	2.06	13	51	22	8
Ss2	2.91	18	57	81	9
Ss3	3.48	17	60	89	21
Ss4	2.03	10	47	85	12
Ss5	2.10	12	53	84	29
Ss6	1.68	11	70	127	53
Ss7	2.02	9	68	96	40
Ss8	1.03	4	52	105	44
Ss9	3.10	15	41	58	7
Ss10	1.94	12	58	-	0
Ss11	3.18	16	57	73	15
Ss12	2.46	11	52	92	16
Ss13	2.25	14	66	94	55
Ss14	2.90	16	53	58	68
Ss15	4.12	14	43	70	14
Ss16	3.97	22	73	33	5
Ss17	1.47	10	53	114	13
ρ	-.256	-.173	.398	.431	.413

9 Conclusions

Concept mapping is one potentially effective tool to promote meaningful learning and at the same time help students develop thinking skills and structure their knowledge. But a lot depends on the students' use of this tool. From the qualitative data accumulated in many years of using concept maps in courses of general chemistry for first years engineering students, I have found that students with very good concept maps—where hierarchical structure, progressive differentiation, and integrative reconciliation are manifested—have a greater probability of passing the final exam. But sometimes students with poor or without concept maps show very strong chemistry knowledge.

From the limited data presented here, no meaningful conclusion can be derived. In literature, many studies find the score of a concept map a reliable tool for assessing students' understanding of science concepts and helpful in finding where learning has occurred and where wrong or incomplete ideas are held by students. (McClure, Sonak and Suen, 1999; Rye and Rubba, 2002) In order to spare the instructor's time, an automatic rule-based evaluation system of student concept maps has been developed. (Cline, Brewster and Fell, 2010) Few studies suggest a qualitative use of concept maps as an indicator of the content that students are learning.

Analyzing the concept maps drawn by 239 students according to four types of responses, associative, emotional, strategic, and meta, we concluded that, because of their individuality, concept maps are largely a qualitative measure (Ritchhart, Turner and Hadar, 2009, p. 157). Johnstone and Otis (2006) considered the didactic relationships between problem-based learning and concept mapping and concluded that the scores from concept maps must be managed with prudence since their use as a measure of the real learning of science is still not certain. A qualitative approach to concept map is still useful to teachers because it can suggest a teaching approach that helps students integrate new knowledge (Kinchin, Hay and Adams, 2000) and serves as an indirect indicator that the students are studying the material.

Another useful tool for probing the students' knowledge structures qualitatively is the word association test. We suggest that the WAT be used only after students have studied the material in the course. As has been shown, this test can reveal the connections, or their absence, between some concepts in the syllabus.

If we as teachers examine the complexity of our profession, we can conclude that teaching cannot be reduced to some formulaic methods and there are no magic recipes. But with humility and enthusiasm we can innovate and improve our teaching using didactic strategies and tools that educational research has demonstrated to be valid. Our goal should be to transform our classes into an educational environment where meaningful learning takes place and students enjoy to be fully engaged. The good news is that this it is possible, but we need to be prepared to work more.

10 Acknowledgement

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COMPETENCE PROFILE DIFFERENCES AMONG GRADUATES FROM DIFFERENT ACADEMIC SUBJECT FIELDS. IMPLICATIONS FOR IMPROVING STUDENTS' EDUCATION[9]

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SUMMARY

The aim of a university education is the intellectual development of citizens, and the training of professionals for their subsequent entry into the workforce. However, this entry into the workforce, following the theoretical education usually provided by the university, implies that students have to manage this difficult transition by themselves.

Society, in a continual process of transformation, requires of universities that they adjust, adapting the education they offer to comply with the demands of society and the workplace. Socio-emotional skills would seem to have influence predicting professional performance. These skills also influence job-finding and employability. Consequently, providing teachers with an education in socio-emotional competences is becoming a necessary task within universities, and the majority of teaching staff consider these skills to be fundamental to the personal and socio-emotional development of students.

The objective of our proposed work is to establish the characteristic profile of competences of a sample of teachers in training, and compare it with the competences profile of graduate students belonging to the fields of law sciences, social sciences, humanities, science and technology, and health. Starting from results, implications will be derived for the development of

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generic competences of socio-emotional type in the framework of the European Frame of Higher Education.

KEY WORDS: Competences profile; Teachers in training; University formation; Socio-emotional competences; Competency Based Teacher Education; Emotional intelligence

1 Introduction and theoretical points

One of the objectives pursued by universities is to promote access to employment. The central role of universities in the European Higher Education Area is to educate the student in terms of acquiring abilities, skills, competences and values, by adopting a new methodology focused on the learning of competences, including socio-emotional competences. (European Union Education Ministers, 1999)

Data from the entry into the workforce surveys highlight the importance of improving competence in IT, languages and social skills whilst also encouraging creativity, management, instrumental skills, decision making and leadership (ANECA, 2005).

According to Ariza (2000) "employability is determined by the interaction of two variables which act as driving elements of the process. On the one hand, the situation of the labour market itself, on the other hand, the adaptation of the candidate's skills to the demands of the labour market".

Authors such as Planas et al (2000) put forward the hypothesis that individuals' formal qualification is less important, because it is a condition that is common to a large mass, instead it is a group of attitudinal and social skills towards work which increase career opportunities (Mora, 1997) as well as further training. Along these same lines, García-Aracil and Van der Velden (2008) point to the fact that students who graduate with greater professional competences achieve higher incomes and demonstrate higher job satisfaction.

Cognitive abilities are very important in the world of work especially when the work is more complex (Gottfredson, 2003; Schmidt and Hunter, 1998), however socio-emotional competences are also critical for the effective performance of most jobs (Ariza, 2001; Cherniss, 2000b), as well as for entry into the workforce and employability (Palací and Topa, 2002; Palací and Moriano, 2003).

Socio-emotional competences are highly valued in the labour market. The majority of jobs not only require technical knowledge and competences, but also a certain level of social and emotional competences (Repetto and Pérez-González, 2007). Even, as pointed out by Cherniss (2000b), a large part of the investment in training by the American industry is spent on training in social and emotional abilities.

The pursuit of maximum performance of workers in the workplace has lead to research into the abilities possessed by the most successful employees who improve the performance of the company. Through analysis of these abilities, several authors (Boyatzis et al. 2000; Goleman, 1995, 1998, 2001; Mayer and Salovey, 1997; Salovey and Mayer, 1990) have come to the conclusion that intelligence, not only general, but also socio-emotional intelligence and personality factors are part of the complex set of competences needed by individuals in order to successfully develop their professional work. The relationship between the emotional competences and performance has been supported by extensive research (Boyatzis, 2008; Brotheridge and Lee, 2008; Cooper, 1997; Dreyfus, 2008; Koman and Wolff, 2008; Murga and Ortego, 2003)

The existing proposals regarding the key competences that professionals should possess come from the knowledge of professional experts and the business world. However, it is in the educational sphere that curricula should be implemented which are able to meet the expectations of the world of work in terms of competences. Precisely one of the main problems encountered by educational institutions when trying to include the learning of generic competences in their curricula is how to evaluate them. Whilst academic competences are easily evaluated, academics wonder how to evaluate aspects which are not directly related to the acquisition of knowledge. This is applies to the ability to build interpersonal relationships, responsibility, stress management, etc. Although there are methodologies aimed at

improving these aspects in the individual, it is difficult for us to incorporate them into the curriculum if we have no way to test the level to which they have been acquired by the students.

Once the skills involved in emotional and social intelligence are linked to performance in personal or professional life, and daily life in general, they constitute competence models (Boyatzis, 1999; Boyatzis, Goleman and Rhee, 2000). In particular, the mixed models of emotional intelligence include broad socio-emotional competences (Mayer, Salovey and Caruso, 2000). Furthermore the majority of the professional competences identified as key competences for professional performance constitute or are very close to the aspects studied within emotional intelligence. In a national survey of American employees, they found that six of the seven competences considered to be key to professional success belonged to emotional intelligence (Ayers and Stone, 1999; Goleman, 1998), but despite this, these competences are not incorporated into the majority of university programmes (Boyatzis, et al. 1995; Echeverría, 2002).

Although professional performance does not seem to be predicted or explained solely by these competences (Schmidt and Hunter, 1998), socio-emotional competences also seem to have a greater explanatory power than the other variables (Caruso and Wolfe, 2001; Goleman, 1998, 2001). These competences also have an effect on other important aspects of the professional career such as entry into the workforce or employability (Caruso and Wolfe, 2001; Fallows and Steven, 2000; and particularly, Hettich, 2000).

The research project "The Flexible Professional in the Knowledge Society: New Demands on Higher Education in Europe", better known as REFLEX, is an initiative which forms part of the 6th Framework Programme of the European Union. In its reports it provides comparative data of up to thirteen European countries classified by students, employers and graduates, amongst others. In these reports reference is made to a subset of generic competences.

Although there is a wide variety of definitions and classifications of competences, and the construct is still subject to debate, there is agreement on the importance of the development of emotional

competences (Bisquerra and Pérez, 2007). In the professional sphere, the term is based on capacity, aptitude, ability, skill or efficiency which bring the individual successful performance at work (González and Wagenaar, 2003; McClelland, 1973; OCDE, 2002; ILO, 2008). For Cano (2005), talking about competences means referring to the ability of the subject to mobilise the resources he has acquired: the knowledge, skills and attitudes, in order to confront and resolve a problematic situation.

Apart from the REFLEX Project there are other classifications of competences. For example, the OCDE (2002) considers the selection of key competences to depend on what societies value, at all times and in all contexts. Currently, some of the most relevant proposals are those proposed by bodies such as the ILO/CINTERFOR (2008) the OCDE (2002), or González and Wagenaar (2003) in the Tuning Project.

Both the type, as well as the extent to which the socio-emotional components create an effect on diverse academic and professional domains, may depend on the area in question. Therefore it is necessary to define in general or specific terms the different aspects on non-academic intelligence, with the aim of identifying both general factors common to the different domains, and the concrete components of social, emotional and practical intelligence, related to each domain or professional field (Boyatzis, Goleman & Rhee, 2000). In order to do this, a profile of socio-emotional competences for each subject-professional field must be established, and the differences or similarities between the different profiles must be analysed.

There are many studies which show that a person's ability to adapt to their environment may be determined by emotional intelligence (Boyatzis, Goleman and Rhee, 2000; Ciarrochi, Chan, and Caputi, 2000). Good adaptability could be the reason for success in the workplace in various fields. Proof of this are the studies conducted by Møller and Powell (2001), Rozeil, Pettijohn and Parker, (2001), and Sjöberg, (2001) in the workplace; Culver and Yokomoto (1999), Lam (1998) and Parker, (2002) in the educational sphere; and Ciarrochi, Deane and Anderson (2002), Parker, Taylor and Bagby (2001) and Salovey, (2001) in the mental health sphere. Moreover, poor adaptability may have negative consequences at work, as is the case with the well known burnout syndrome (Aluja, Blanch, Biscarri, 2002). Other studies which analyse

how good management of stress or other emotional variables avoid or reduce stress or depression at work, and relate it to these variables in professional spheres as diverse as the health sphere (Aiken et al. 2002; Gil-Monte, 1991) and the educational sphere (Durán, Montalbán, Rey, Extremera, 2005).

In the professional sphere of teaching, the relationship between the emotional intelligence and the personal adjustment and the wellbeing of the teacher has begun to be examined (Palomera, Fernández-Berrocal and Brackett, 2008). Although there is no history in Spain of research into these competences, in the Anglo-Saxon countries, with the United States in the lead, there has been important and sound research in this regard, especially over the last decade (Repetto and Pérez-González, 2007). Proof of this is that the United States spends around 50 trillion dollars each year on training, largely focused on social and emotional abilities (Cherniss, 2000a). Other studies which analyse the relationship between emotional intelligence and burnout in secondary school teachers (Chan, 2006), show how burnout has a negative influence on student performance and the quality of their teaching; as well as on the teacher's wellbeing (Vanderberghe and Huberman, 1999) and the teacher-student interpersonal relationships (Yoon, 2002).

Weare and Grey (2003) in a study conducted on the development of competences conclude with the recommendation of explicitly developing both social and emotional competences, not only in the school but also in the teacher training institutes, based on the idea that it is not possible to teach a competence which one has not yet gained, just as quality teaching is not possible without the wellbeing of the teacher.

One of the other studies focused on the teaching profession is that conducted by Jennings and Greenberg (2009), and also that of Sutton and Wheatley (2003) which highlight the close relationship between the social and emotional competences of the teachers and the effectiveness and quality when the classroom teaching and learning processes are being carried out, as well as the development of the pro-social behaviour of the students in class. Di Fabio and Pazazzeschi (2008) evaluate the relationship between emotional intelligence and self-efficacy in a sample of Italian teachers. A similar study is carried out by Chan (2008) who studies the relationships between emotional intelligence, self-efficacy

and coping skills in teachers in Hong Kong. In Spain, the study on perceived emotional intelligence and life satisfaction in university lecturers by Landa, Lopez-Zafra, Martinez de Antonana and Pulido (2006) should also be mentioned.

Despite the importance that is given to emotional intelligence for the development of the professional activity of teaching there are few programmes aimed at training teachers. In our sphere there are several researchers who have noted the need to develop the emotional intelligence of teachers starting from initial training, as part of the general competences set by the EHEA (Bisquerra, 2005; Bueno, Teruel and Valero, 2005; Extremera and Fernández-Berrocal, 2004; Pesquero, Sánchez, González and Martín, 2008; Sala and Abarca, 2002; Teruel, 2000; Vivas, 2004). However, concrete proposals on how to include these competences in the curriculum for teachers still need to be established, despite the fact that in some cases it has been clearly demonstrated that training novice teachers in emotional competences has shown its effectiveness not only in increasing their own emotional competence, but also in predicting a smooth transition from the student role to professional life (Byron, 2001).

Thus the objective of our study is to establish the characteristic profile of competences of a sample of teachers in training, and compare it with the profile of competences of graduate students belonging to the fields of legal sciences, social sciences, humanities, science and technology, and health. Starting from results, implications will be derived for the development of generic socio-emotional competences of socio-emotional type in the framework of the European Frame of Higher Education.

2 Method

2.1 Participants

The sample consisted of students from the University of Alicante, enrolled on the final year of their degree. The students are from different degrees which have been grouped into the following subject-professional fields: Law Sciences (Law and Criminology) 96 students, Social Sciences (Economics and Sociology), 144 students, Education

(Teaching in Early Childhood, Primary and Secondary Education), 180 students, Humanities (History, Geography, Spanish Language), 62 students, Science and Technology (Biology, Computer Engineering and Architecture), 189 students, and Health Sciences (Nursing and Nutrition), 158 students. The total number of students in the sample is 829. The students have an age within the range 20 to 52 years and a mean age of 26 years. 54% are women and 46% are men.

2.2 Instruments

To assess the socio-emotional competences of students the following instruments were used.

The *Trait Meta-Mood Scale-24* (TMMS-24) is a version of TMMS-48 (developed by Salovey and Mayer) adapted and shortened by Fernández-Berrocal, Extremera and Ramos (2004). This self-report measure assesses three key dimensions of emotional intelligence: emotional attention, emotional clarity, and repair / emotional control. The subjects were asked to evaluate the degree to which they agreed with each of the items on a Likert-type scale of 5 points (1 = Strongly Disagree, 5 = Strongly Agree). After having been shortened, the scale has shown increased reliability in all its factors: Attention (.90), Clarity (.90), and Repair / Control (.86).

The *Emotional Quotient Inventory*: Short (EQ-i: S) by Reuven Bar-On (2002) is a short version of the *Emotional Quotient Inventory* which has been adapted into Spanish by MHS, Toronto, Canada. It consists of 51 items rated on a Likert-type scale of 5 points and assesses five broad factors of emotional intelligence: Intrapersonal Skills, Interpersonal Skills, Adaptability, Stress Management, and General Mood or Optimism. The EQ-i:S shows adequate validity, and internal consistency, assessed with Cronbach's alpha index, ranges between .65 and .86.

2.3 Procedure

To collect the data from the students, direct contact was made with the teaching staff of the final year subjects, in each specialisation. The subjects chosen were those that provided a high number of students since they were core subjects. Once consent was given by the teacher,

appropriate dates were chosen so that the tests could be performed during class time, when the number of students per classroom would be at its highest. Data collection was performed during the first term of the year, both in the morning and the afternoon, conducting the tests in their respective classrooms. The subjects were given sufficient time to perform the tests; giving them a maximum time of approximately two hours to complete all of the tests.

2.4 Design and data analysis

Different data analysis techniques have been used in this study, within a design that can be considered, in general, comparative ex post facto.
First the profiles of each of the eight groups were established taking into account the different variables measured. To obtain the profile the scores of all of the variables were converted into a scale of 1 to 10 points which enabled direct comparison between the scores of the different aspects of emotional intelligence assessed.

To compare the profiles of the different groups the GLM – General Linear Model – module of the SPSS v.15.0 statistical package was used. Using this procedure a multivariate analysis of variance (MANOVA) and a univariate analysis of variance (ANOVA) with repeated measures were performed, in which the measures of the socio-emotional variables are treated as variables measured within the subjects, and the groups of students from the different fields act as between-subject variables.

3 Results

Table 1 shows the means and standard deviations obtained by each group of students in the different variables. The mean scores of the students range from 5.87 for the group of students in the science and technology field in the emotional attention variable and 8.77 for the students in the legal science and education fields in interpersonal intelligence. In general, for all subject fields, the highest means correspond to interpersonal intelligence and the lowest to emotional attention. We should bear in mind that high attention to one's own emotions does not seem to be associated with better emotional intelligence.

Table 1. Descriptive statistics, means and standard deviations (in brackets), for each subject-professional field.

	Law Sciences	Social Sciences	Education	Humanities	Science & Technology	Health Sciences	Total score
Attention	6.32 (1.5)	6.39 (1.4)	6.74 (1.4)	6.50 (1.5)	5.87 (1.4)	6.81 (1.4)	6.43 (1.5)
Clarity	7.10 (1.4)	6.64 (1.3)	6.76 (1.3)	6.76 (1.4)	6.74 (1.4)	6.90 (1.3)	6.80 (1.4)
Repair/ control	7.47 (1.3)	7.10 (1.5)	6.83 (1.4)	6.77 (1.3)	6.94 (1.5)	6.87 (1.3)	6.98 (1.4)
Intraper. Skills	7.96 (0.9)	7.59 (1.0)	7.38 (1.1)	7.55 (1.1)	7.28 (1.2)	7.50 (0.9)	7.50 (1.0)
Interper. Skills	8.77 (0.8)	8.51 (0.8)	8.77 (0.7)	8.59 (0.6)	8.28 (0.7)	8.64 (0.7)	8.58 (0.7)
Adaptabilit y	8.05 (1.1)	7.74 (1.0)	7.24 (1.0)	7.60 (0.9)	7.85 (1.0)	6.90 (1.0)	7.73 (1.0)
Stress Managem.	7.33 (1.5)	7.18 (1.5)	7.60 (1.3)	6.94 (1.4)	7.38 (1.4)	7.57 (1.4)	7.19 (1.4)
General Mood	8.14 (1.0)	7.99 (1.0)	7.76 (1.1)	7.69 (1.0)	7.87 (1.0)	7.81 (1.0)	7.87 (1.0)
Total score	7.64 (1.2)	7.39 (1.2)	7.38 (1.1)	7.30 (1.1)	7.28 (1.2)	7.37 (1.1.)	

Taken by subject fields, the legal science students, in general, seem to have high values in most of the socio-emotional variables, except for emotional attention ($\overline{x}$ = 6.32). Students from the educational field (early childhood, primary and secondary teachers) demonstrate a profile with scores that are below the total means in most of the variables, except in interpersonal intelligence ($\overline{x}$ = 8.77).

To compare the profiles of students from different subject-professional fields a multivariate analysis of variance (MANOVA) and univariate analysis of variance (ANOVA) with repeated measures were performed.

In relation to evaluation of assumptions of this analysis, the Box's M test to test the homogeneity of variance-covariance matrices was non-significant ($F_{(180,405618)}$= 1.107, p= 0.15). However, the Mauchly's sphericity test showed a result of χ^2 = 1213.84, df= 27, p= .000, thus not fulfilling the assumption of sphericity of the matrix of dependent variables. Therefore, the within-subject test for the effects of flatness

(socio-emotional effect) and parallelism of profiles (effect of interaction socio-emotional*field) was performed with the degrees of freedom corrected with the Epsilon adjustment values.

Table 2. Tests of within-subjects effects

Source of variation		*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Partial* η^2	*Observed Power* (α)
Socio-emotional	Sphericity assumed	2324.55	7	332.08	282.94	.000	.25	1.00
	Greenhouse-Geisser	2324.55	4.91	473.27	282.94	.000	.25	1.00
	Huynh-Feldt	2324.55	4.97	467.27	282.94	.000	.25	1.00
	Lower Limit	2324.55	1.00	2324.55	282.94	.000	.25	1.00
Socio-emotional * field	Sphericity assumed	197.64	35	5.64	4.81	.000	.02	1.00
	Greenhouse-Geisser	197.64	24.55	8.04	4.81	.000	.02	1.00
	Huynh-Feldt	197.64	24.87	7.94	4.81	.000	.02	1.00
	Lower Limit	197.64	5.00	39.53	4.81	.000	.02	.98
Error	Sphericty assumed	676.33	5761	1.17				
	Greenhouse-Geisser	6761.33	4042.29	1.67				
	Huynh-Feldt	6761.33	4094.19	1.65				
	Lower Limit	6761.33	823.00	8.21				

α Alpha = .05

Table 2 shows the within-subject effects, and non flatness and non parallel profiles are observable. Variations in the DVs have proved significant for all statistics in the flatness test ($F = 282.94$; $p < .05$ y η^2 partial = .25). These profiles are shown graphically in Figure 1, in which we can observe both the profile of education students and that of those from the other subject fields. Also significant were the variations in the socio-emotional variables for each subject field in all of the statistics shown from the parallelism test. ($F = 4.81$; $p < .05$, partial $\eta^2 = .02$).

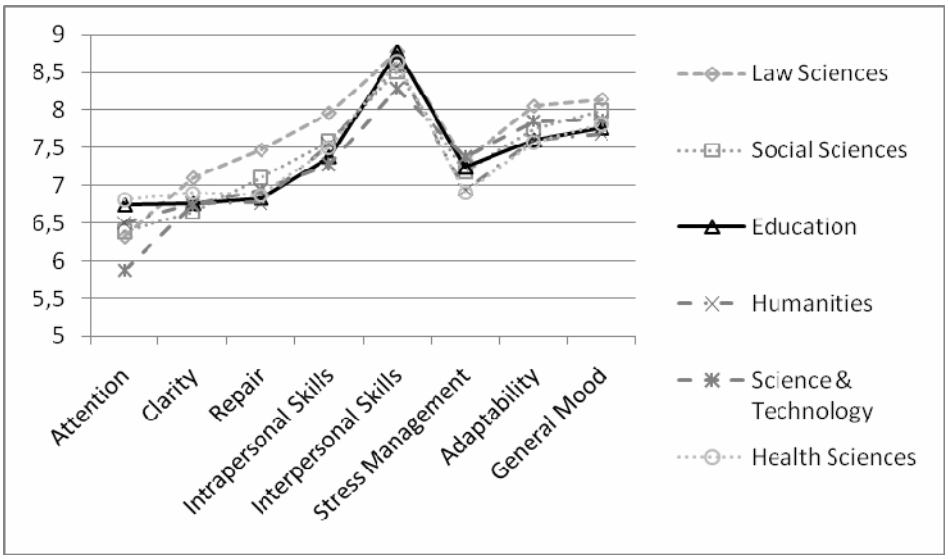


Figure 1. Graph of the social-emotional intelligence profiles by subject field.

To evaluate deviation from parallelism of the socio-emotional profiles, confidence limits were calculated around the mean of the profile for the six groups combined. Alpha error for each confidence interval was set to .0015 to achieve an experimentwise error rate of 5%. Therefore, 99.85% limits were evaluated for the pooled profile (Tabachnick & Fidell, 2007). Confidence intervals for each socio-emotional variable of the pooled profile are shown in Table 3.

Table 3. Estimated marginal means

Socio-emotional variables	Mean	Error	Confidence interval 99,85%.	
	Límite inferior	Límite superior	Lower Limit	Upper Limit
Attention	6.44	.05	6.26	6.61
Clarity	6.82	.05	6.65	6.98
Control	7.00	.05	6.83	7.17
Intrapersonal skills	7.54	.04	7.42	7.67
Interpersonal skills	8.59	.02	8.51	8.68
Stress Management	7.16	.05	6.99	7.33
Adaptability	7.74	.03	7.61	7.86
General Mood	7.88	.03	7.75	8.00

Table 4 shows the socio-emotional profile for every subject field. The cells marked with "*" indicate that the mean falls outside the limits of the confidence interval. With regard to the Education students, the attention, intrapersonal skills, interpersonal skills, and adaptation variables fell outside the limits of the confidence intervals of the pooled profile, that is, their means were significantly different from the mean of all students. The Education students, as well as the Health Science ones, had a significantly higher mean on attention than that of the pooled groups. Likewise, Education students had a significantly high score on Interpersonal skills, sharing the same mean as that of the Law Sciences students. On the other hand, they had a significantly lower mean on Intrapersonal Skills than that of the pooled subject fields (as well as the Science & Technology students). They were also slightly low on adaptability; this fact also occurred with the Humanities and Health Sciences students. As far as the rest of variables are concerned, that is, Clarity, Control, Stress management, and General mood, Education students' scores fell inside the confidence interval of the pooled profile, so the differences with the pooled profile could have been due to chance.

Table 4. Profile Means

	Subject field						
	Education	Law sciences	Social sciences	Humanities	Science & Technology	Health sciences	Total
Attention	6.74*	6.32	6.39	6.50	5.87*	6.81*	6.43
Clarity	6.76	7.10*	6.64*	6.76	6.74	6.90	6.80
Control	6.83	7.47*	7.10	6.77*	6.94	6.87	6.98
Intrapersonal skills	7.38*	7.96*	7.59	7.55	7.28*	7.50	7.50
Interpersonal skills	8.77*	8.77*	8.51	8.59	8.28	8.64	8.58
Stress management	7.24	7.33	7.18	6.94*	7.38	6.90*	7.19
Adaptability	7.60*	8.05*	7.74*	7.60*	7.85	7.57*	7.73
General Mood	7.76	8.14*	7.99	7.69*	7.87	7.81	7.87

*Variables whose mean fall outside the limits of the confidence interval defined in Table 3.

With regard to the test of level, or between subjects effect, (Table 5), there are differences between the means of the groups in all the socio-emotional variables. However, this difference is minimal given that the effect size of the factor of belonging to the subject field (partial $\eta^2 = .02$) is very small.

Table 5. Tests of between-subjects effects

Source	Type III Sum of Squares	df	Mean Square	F	p	Partial η^2	Observed Power (α)
Intercept	311335.10	1	311335.10	85083.35	.000	.99	1.000
Field	72.93	5	14.58	3.98	.001	.02	.950
Error	3011.50	823	3.65				

α Alpha = .05

To analyse the differences between the education students and students from the other subject fields Scheffé's univariate contrast was performed (Table 6). This comparison shows how education students possess a different, statistically significant, level of socio-emotional competences, compared to the other subject fields. The differences in competences are found with the legal sciences students in emotional control, intrapersonal intelligence and adaptability, in which education students are below the legal sciences students. The other subject field with which differences are found is science and technology; in this case education students are above these students in interpersonal intelligence and attention to their own emotions. As for the fields of social sciences, humanities and health sciences, no statistically significant differences with the education students are found in any of the variables analysed.

Table 6. Univariate contrast of Scheffé to test mean differences

Field	Law sciences	Social sciences	Humanities	Science & Technology	Health sciences
Attention	.43	.43	.25	.90*	-.04
Clarity	-.34	.06	.01	.01	-.14
Control	-.62*	-.22	.09	-.08	-.03
Intrapersonal skills	-.57*	-.24	-.17	.09	-.11
Interpersonal skills	-.00	.26	.17	.48*	.12
Stress management	-.08	.01	.30	-.10	.30
Adaptability	-.43*	-.14	.01	-.23	.01
General Mood	-.38	-.23	.05	-.12	-.05

* Significant difference at .05.

4 Discussion and conclusions

Taken as a whole, the results show that students in the educational field demonstrate a similar or lower profile of socio-emotional competences than students in the other subject-professional fields, excelling only in interpersonal skills, in which they are equal to the students in the legal sciences field. Likewise, they also show greater attention to their own emotions, along with the health sciences students.

The legal sciences students seem to have high values in most of the socio-emotional variables, whilst education students demonstrate a profile with scores that are below the total averages in most variables, except in interpersonal intelligence.

Education students are below the legal sciences students in the emotional control, intrapersonal intelligence and adaptability variables, and above the science and technology students in interpersonal intelligence and attention to their own emotions. Whilst in the fields of social sciences, humanities and health sciences, there are no statistically significant differences with the education students. On the one hand, it might seem logical that education students are those who perceive

themselves to have the greatest ability to pay attention to their emotions and distinguish how they feel at every moment, given that due to their future professional work they will be required to be in constant contact with younger students whose emotions must be monitored; however, paying too much attention to one's emotions can be detrimental to the person.

Given the importance of the socio-emotional competences for the adequate development of teachers' work, and the relatively low level that trainee teachers demonstrate, it seems necessary to create programmes to develop these competences within the students' curriculum. Emotional intelligence involves the development of a set of skills that every teacher should learn for two reasons: firstly because the classroom is the model of adult social-emotional learning which has the greatest influence on students, and secondly because research shows that adequate levels of emotional intelligence help individuals to cope more successfully with the daily setbacks that teachers face in the educational setting (Extremera and Fernández-Berroca, 2004).

Some Anglo-Saxon programmes (also in Spain, Vallés, 2003) emphasize the integral skills to the concept of emotional intelligence proposed by Mayer and Salovey as a useful tool for coping with personal and interpersonal conflict in educational centres and for the complete development of the student. However, there are still very few educational institutions to have established specific programmes which promote the necessary skills in the teacher to employ an education style that emphasizes emotional development (Sala, 2002).

On the other hand, recent studies argue that managers who prove to be "Highly Effective" start to develop their skills at an early age and prior to their professional experience (Dreyfus, 2008). However, although consensus on the importance of emotional competences is high (Palomera, Fernández-Berrocal, and Brackett, 2008), developing this type of training depends on the entire educational community involved in the process, from schools to universities, both of which often experience great difficulty (Elias *et al*., 1997; Zins, Weissberg, Wang, & Walberg, 2004).

Therefore it seems justified to develop the socio-emotional skills in the university curriculum, given the importance of these skills for career development. The question then arises of how to incorporate generic socio-emotional skills into the university curricula established within the framework of the European Higher Education Area. Although there are several initiatives in this regard (Fallows and Stevens, 2000; Jaeger, 2003), these have been implemented in areas other than education. Even though most of the programmes argue that the development of these competences should be integrated into conventional academic work, the normal curriculum, and supplemented through extracurricular learning (Fallows and Stevens, 2000).

Thus it seems necessary to introduce teaching methods into future teacher training which are capable of promoting the development of socio-emotional competences. We suggest, for example, the use of the expository and lecture methods to develop self-awareness and emotional self-control. To develop the skills related to teamwork and interpersonal relationships we suggest cooperative work, group dynamics, and others; methodologies which purport to show how certain educational and social objectives can be achieved by coordinating actions that otherwise could not be achieved; in other words, how the outcome of teamwork achieves benefits sought and shared by all. To develop competences related to negotiation and conflict resolution, we propose a methodology based on case studies, problem solving, etc. To develop competences related to decision making, interpersonal relationships, adaptability and assertiveness we suggest project-based learning. And for the development of competences related to assuming responsibility, self-control and motivation we suggest the use of autonomous learning.

Finally it is important to remember that if universities seek to train their students in the competences sought by businesses, initial teacher training should include emotional competences if we are to be consistent with that which research has taught us, that which the education laws require of us and the model of European society we are in pursuit of (Palomera, Fernández-Berrocal, and Brackett, 2008).

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MAKING INSTRUCTIONAL EXPLANATIONS EFFECTIVE.

The Role of Learners' Awareness of their Misunderstandings.

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ABSTRACT

Although instructional explanations have potential advantages, there is evidence that they do not work effectively. One possible interpretation is that learners do not profit from explanations because they are not aware of the problems in their understanding that the explanations are intended to revise. If this is correct then one can expect explanations combined with prompts making learners' misunderstandings explicit to be more effective than those not combined with prompts. In order to test this hypothesis we conducted an experiment in which undergraduate students learned geology from a multimedia presentation. The presentation also included instructional explanations aimed at revising learners' misunderstandings, which were presented in combination with prompts (prompted explanation) or in isolation (rough explanation). After studying the presentation participants solved retention and transfer tests. Results revealed that participants receiving prompted explanations outperformed those receiving rough explanations. This indicates that learners need to be aware of the limitations in their understanding if they are to profit from an instructional explanation.

KEY WORDS: Instructional explanations; Deep learning; Monitoring; Regulation; Support devices.

1 Introduction

Instructional explanations are given in response to learners' problems of understanding. Despite their potential advantages, such as providing repairing inferences when learners are stuck, instructional explanations have been found to be ineffective more often than not. In order to interpret why this is so, two reasons can be put forth. First, explanations are not adapted to address learners' specific problems of understanding. Second, explanations are not provided after pointing out the misunderstandings. The first reason has been supported by empirical data. However, the second reason requires empirical confirmation, albeit there is some suggesting evidence in favor of it. The goal of the present experiment was to gather empirical support for that reason. In other words, the goal was to answer the following question: are instructional explanations more effective when the learner is aware of the misunderstandings they are intended to revise? As long as this is confirmed, a theoretical implication can be that learners need to be aware of the problems in their understanding in order to profit from instructional explanations; a practical implication can be that instructional explanations have to be provided after learners' problems of understanding have been pointed out if they are to be effective.

2 What is meant by instructional explanations?

Explanations describe cause-and-effect systems, such as physical or social phenomena. Instructional explanations, which are the explanations we are interested in, are those descriptions of cause-and-effect systems designed specifically to elicit learning (Leinhardt, 1997; Leinhardt & Steele, 2005). For our purposes, this is a vague definition, albeit correct. The definition includes at least two kinds of instructional explanations. One kind of explanation is that given as a first account of a phenomenon, that is, an explanation which makes learners get familiar with a topic –one might call this *presentation*. Another one is that given in response to an observed or anticipated misunderstanding, in other words, an explanation which revise and repair learners' emerging understanding of the topic in question –one might call this *clarification*.

In the present chapter we use the term instructional explanations to refer to clarifications given in response to problems of understanding.

Finding ways of making (this kind of) instructional explanations effective is relevant for two reasons. First, they are ubiquitous in instructional settings. For instance, summaries recapping main ideas in texts (Lorch, Lorch, & Inman, 1993), elaborations revealing the rationale behind solution steps in worked-out examples in computerized learning environments (Renkl, 2002), tutors' contributions revising learners' understanding in human tutoring (VanLehn, Siler, Murray, Yamauchi, & Baggett, 2003) or explanatory feedback to learners' responses to questions in computer-based learning environments (Moreno, 2004) may be considered forms of instructional explanations.

Second, instructional explanations present potential advantages. On the one hand, they can provide learners with correct, complete and coherent information. On the other hand, they can do so at the right moment: when learners are aware of the limitations in their ongoing understanding but cannot generate repairing explanations by themselves. This potential advantage is very important, since there is strong evidence that learners who detect problems in their emerging understanding generate inadequate repairing explanations (Otero & Campanario, 1990; Renkl, 1997) or even no explanations at all (Coté, Goldman, & Saul, 1998; Kintsch & Kintsch, 1995).

3 Are instructional explanations effective?

Despite these potential advantages, evidence regarding the effectiveness of instructional explanations is mixed. Sometimes providing learners with instructional explanations is beneficial for learning. Lorch et al. (1993) had participants learn about methods of energy production by reading texts. Half of the texts included interjected summaries recapping the main ideas; the other half did not. Participants receiving summaries outperformed their counterparts. In the experiment of Renkl (2002) participants learned about probability by studying worked-out examples. Half the participants received elaborations revealing the rationale behind the solution steps of the examples; the other half studied the examples without elaborations. Those in the condition with

elaborations performed better in a transfer test, as compared to their counterparts.

Nevertheless, there is also ample evidence that instructional explanations have a neutral impact on learning. Chi, Siler, Jeong, Yamauchi and Hausmann (2001) asked participants to learn about the human circulatory system. They first read a textbook and then maintained tutoring sessions with experts in the domain. In one of two conditions tutors provided participants with both scaffolding (e.g., questions, hints, corrective feedback) and instructional explanations; in the other condition tutors were prevented from giving explanations. There were no differences between the two conditions in terms of the learning gains exhibited by participants; therefore, explanations made no difference. VanLehn et al. (2003) had participants learn physics by solving problems with the assistance of a human tutor. The correlation between different events occurred in the tutoring sessions (e.g., tutors' explanations, goals stated by tutors, errors made by learners) and participants' learning gains was calculated. VanLehn et al. found that tutors' explanations were not associated with learning. Gerjets, Catrambone and Scheiter (2006) had participants learn about probability by studying worked-out examples. Some participants were provided with explanations showing the rationale behind the solution steps; others received no explanations. The impact of instructional explanations was null. Grosse and Renkl (2006) asked participants to learn probability calculation from worked-out examples with multiple solutions. Half the participants received explanations pointing out the pros and cons of each solution procedure; the rest received no explanations. The presence of instructional explanations made no difference to learning outcomes.

In the light of these results, the effectiveness of instructional explanations can be put into question. More often than not, instructional explanations have a neutral effect on learning.

4 Why are instructional explanations ineffective?

In interpreting why instructional explanations usually have no impact on learning two reasons can be suggested (Wittwer & Renkl, 2008). One possible explanation is that instructional explanations are not adapted to

learners' needs. Simply put, the contents in instructional explanations are not those required to revise and repair the flaws in learners' emerging understanding; instead, they are irrelevant ones. This explanation seems plausible if one considers that instructors are not so much able to monitor learners' ongoing understanding, as shown in a study conducted by Chi, Siler, and Yeong (2004). Chi et al. had participants learn about the human circulatory system from a textbook with the help of a human tutor. In between the tutoring session, the tutors were asked to answer a set of questions as if they were the tutees. Independently, the tutees were asked to solve the same set of questions. The researchers found that tutors' responses were very different from tutees' responses indicating that tutors find it difficult to keep track of their tutees' understanding. If this is so, then one can expect instructional explanations provided by instructors to be of little help.

Another possibility is to think that instructional explanations are not presented in a responsive manner. The rationale behind this is the following. In order to profit from an instructional explanation, learners have to be aware of their need for explanatory support; that is, learners have to detect limitations in their ongoing understanding. When this is done, learners see explanations as repairing information, thus profiting from them. If learners do not detect their misunderstandings, they see instructional explanations as ancillary information. As a consequence, they do not profit from them. Therefore, explanations may be ineffective because they are provided without helping learners to see what aspects in their understanding they are to revise. This interpretation seems plausible in the light of the compelling evidence that learners find it difficult to monitor their emerging understanding. Commander and Stanwyck (1997) had participants study a textbook on psychology and rate their learning. Then participants solved a test and their scores were compared with their ratings: almost half of the participants wrongly estimated their actual learning. Otero and Kintsch (1992) asked participants to evaluate short texts containing explicit contradictions. More than two-thirds of participants evaluated the texts as intelligible. In the light of this evidence, one can expect learners to conceive instructional explanations as ancillary material.

In sum, instructional explanations may be ineffective because they are not tailored to learners' needs and they are not presented responsively.

An important question is whether there is evidence confirming this interpretation.

5 Is there evidence supporting the interpretation?

First, there is evidence that instructional explanations adapted to suit learners' needs are better than those not adapted. In an experiment conducted by Nückles, Wittwer and Renkl (2005) participants interacted with an expert in order to learn about internet. In one condition the expert had access to learners' profiles, which informed him about learners' level of prior knowledge; in the other condition the expert knew nothing about learners' prior knowledge. Those experts who had access to learners' profiles could adapt their explanations to learners' needs (i.e., aspects in which their knowledge was especially low), which was not possible for those in the other condition. The results showed that learners receiving explanations from informed tutors learned significantly more, with respect to their counterparts. This was further confirmed in a recent experiment (Wittwer, Nückles, & Renkl, 2008). In this experiment some experts received accurate learners' profiles whereas others received biased learners' profiles, which either overestimated or underestimated learners' actual level of knowledge. Again, participants receiving explanations from well informed experts outperformed those receiving them from biased experts, regardless of if they overestimated or underestimated their level of prior knowledge. This evidence supports one of the reasons that can be suggested for the problem of instructional explanations' ineffectiveness.

Second, there is evidence that instructional explanations work effectively when learners are aware of the flaws in their understanding that the explanations are intended to revise. As described before, in the study of VanLehn et al. (2003), participants learned physics by solving problems and received help from a human tutor. The correlation between different events in the tutoring sessions and learning gains were calculated. Tutors' explanations were not correlated with learning; however, those given in the context of an impasse (i.e., situation in which learners realize they are wrong or stuck) did. In other words, instructional explanations worked effectively when learners' were aware of their misunderstandings, which allowed them to see the explanations

as repairing information, thus profiting from them. This is consistent with the other reason that can be suggested to interpret instructional explanations' ineffectiveness; however, it might be argued that the evidence is not strong enough, as will be shown later.

6 What is the theoretical basis for this interpretation?

According to the *mental model repair view* (Chi, 2000; deLeeuw & Chi, 2002; see also Hacker, 1998; Otero, 2002), self-regulated learning from an instructional material involves two key processes. On the one hand, learners have to monitor their ongoing understanding to *detect* gaps and flaws. On the other hand, learners have to generate explanations to *repair* these gaps and flaws. Presenting instructional explanations in a responsive manner may be considered an aid to the process of detecting, as pointing out learners' misunderstandings before providing the explanation help them in monitoring their emerging mental representations. Similarly, adapting explanations to learners' needs may be seen as an aid to the process of repairing, as adapted explanations provide learners with the building blocks necessary to revise their emerging mental representations. So, in keeping with the mental model repair view, an interpretation for the ineffectiveness of instructional explanations can be that they do not help learners in detecting and repairing the gaps and flaws in their ongoing understanding.

7 The present experiment

Although instructional explanations have potential advantages, they usually have been found to be ineffective. In order to explain such pattern two reasons can be suggested. One is that they are not tailored to learners' needs, which was supported by empirical data (Nückles et al., 2005; Wittwer et al., 2008). Another one is that they are not presented after learners' misunderstandings have been pointed out. The results of one study are in line with this interpretation, however, it may be problematic to consider these results conclusive. VanLehn et al. (2003) found that instructional explanations given after learners had realized they are wrong (impasse) were associated with learning. Nevertheless,

this should be taken with caution for the following reason. The problems learners had to solve in the tutoring sessions of the study corresponded to different principles in physics (e.g., deceleration, compound body) while the relationship among instructional explanations, impasses and learning gains was only true for two of four principles. Therefore, it is possible to think that there was something in the principles where explanations worked that made explanations especially helpful. If so, it is not true that explanations are more effective after learners' realize they are stuck; instead, there are principles of physics for which tutors' explanations in impasses work especially well. For this reason, it seemed warranted to strictly explore whether instructional explanations are more effective when learners' misunderstandings have been pointed out. In other words, the goal of the present experiment was to gather support for one of the reasons that can be suggested to explain the failure of instructional explanations to promote learning: is it true that instructional explanations are more effective when learners' realize that there are flaws in their understanding? If this is confirmed then one implication can be that learners need to be aware of their misunderstandings if they are to take advantage of instructional explanations. Another implication can be that instructional explanations have to be combined with devices making learners' misunderstandings explicit in order to work effectively.

It should be noted that a prior experiment conducted in our lab explored this question (Sánchez, García Rodicio, & Acuña, 2009). The results confirmed that instructional explanations are more effective when the flaws in learners' understanding that they are to solve are previously pointed out. Nevertheless, given the importance of its implications for instructional practice, we find it warranted to replicate the finding.

In order to examine the question we carried out the following experiment. We asked undergraduate students to learn geology (plate tectonics) from a computer-based multimedia presentation. The presentation included both (a) modules consisting of static pictures with accompanying on-screen text and (b) instructional explanations. The explanations were inserted in between the modules and were designed to address typical misunderstandings (which were identified on the basis of prior studies). In the *prompted explanation* condition instructional explanations were preceded by prompts making the learners' potential misunderstandings explicit; in the *rough explanation* condition

instructional explanations were provided in isolation. After studying the presentation, we asked participants to solve retention and transfer tasks. Based on the arguments above, we expected participants in the prompted explanation condition to outperform those in the rough explanation condition.

8 Method

8.1 Participants and design

Twenty-seven undergraduate students enrolled in a course of educational psychology in the University of Salamanca participated in the experiment. They were paid 5€ for their participation. The mean age of the sample was 19. The sample was 78% female and 22% male. Thirteen participants served in the prompted explanation condition whereas 14 served in the rough explanation condition.

We used a one factor design with condition (prompted explanation versus rough explanation) as the between-subjects factor. Performances in the retention and transfer tests and time taken on instructional explanations were used as dependent variables.

8.2 Materials

The *prior knowledge test* was a paper-and-pencil test comprising eight questions. These questions required participants to both write and draw. They covered three key subtopics within the topic of plate tectonics, namely, (a) basic notions such as that of plate, convection currents and plate motion and collisions (e.g., "What is a tectonic plate?"); (b) the differences between continental-continental and oceanic-continental plate collisions (e.g., "How are mountains formed?"); (c) the recycling loop between the activity in the ridges and that in the trenches (e.g., "How could the Earth's surface get recycled?").

The *computer-based multimedia presentation* consisted of seven modules comprising slides that included static pictures with accompanying on-screen text. The modules described (1) the three layers in the internal structure of the Earth and their relations, (2) the convection currents, (3) the ridges and the process through which new crust is created, (4) the convection currents as the origin of plates' movements and collisions, (5)

the collision between a continental and an oceanic plate and its consequences on the Earth's surface, the Andes range as an example of this type of collision, (6) the destruction of crust in the trenches, (7) the collision between two continental plates and its consequences on the Earth's surface, the Himalaya range as an example of this type of collision. As the reader can see, the modules (1), (2) and (4) can be classified in the subtopic (a) (basic notions); the modules (5) and (7) can classified in the subtopic (b) (differences between plate collisions); the modules (3) and (6) were classified in the subtopic (c) (recycling loop). Appendix A includes a screenshot of the multimedia presentation. Time of exposure for each slide in the modules was predetermined. Overall, the presentation lasted approximately 15 minutes.

The understanding we wanted participants to gain from the presentation was this. "The Earth's core is a big sphere made of iron and is very warm. The core makes the magma (i.e., a doughy substance made of melted rocks) in the mantle heat up and, thus, approach the Earth's surface or crust. When the magma gets cold again, it moves away from the crust. As a result, convection currents are formed through which the magma is continuously moving up and down. The magma in the mantle surfaces through ridges (i.e., breaks in the crust) because of the movement provoked by currents. Once it is in the surface, the magma gets colder and solidifies creating new crust. Convection currents also push the plates, as these are floating on the magma, making them move away from each other. When moving, plates can collide with other plates. There are different kinds of collisions depending on the plates engaged in the crashes, namely, oceanic-continental or continental-continental. Thus, plates can collide and one sinks (in the trenches) inside the Earth originating mountains with volcanoes (e.g., the Andes range); or they can collide and move vertically originating mountains without volcanoes (e.g., the Himalaya range). When a plate sinks in the trenches it is destroyed and becomes magma again whereas the magma surfacing through the ridges solidifies creating new crust. This means there is a continuous recycling loop between the trenches and the ridges."

The presentation also included *instructional explanations*. They were interjected in between the modules (specifically, after the modules (3), (6) and (7)). These instructional explanations were designed to revise potential learners' misunderstandings. In order to identify these

misunderstandings the following procedure was followed. Participants in pilot studies (see Sánchez et al., 2009) were provided with different instructional materials on plate tectonics. After studying the materials, these participants were asked to solve a set of questions. An analysis of their answers made it possible to elaborate a list of typical misunderstandings. These were: (a) the notion of ridge was distorted (learners thought of ridges as if they were isolated, small cracks over the Earth's surface), (b) the differences between continental-continental and oceanic-continental plate collisions were underestimated (learners thought of the different plate collisions as if they were similar), (c) the recycling loop was not completely understood (learners could not see the link between the activity in the ridges and that in the trenches). Accordingly, three instructional explanations were created in order to revise and repair these common misunderstandings. One of these explanations is transcribed in Appendix B.

The *retention test* was a paper-and-pencil test comprising six open-ended questions. These questions tested on the main ideas explicitly covered in the multimedia presentation. The questions covered the three key subtopics in plate tectonics (e.g., "Why are tectonics plates moving and crashing permanently?", "What are the differences between the plate collision in the Himalaya and that in the Andes?", "How could the Earth's surface get permanently recycled?").

The *transfer test* was a paper-and-pencil test comprising ten open-ended questions. These questions required participants to use the knowledge they had gained to solve novel problems. The questions again covered the three key subtopics (e.g., "Imagine that tectonics plates stop moving, how would you explain that?", "Could the Himalaya range have volcanoes?", "What would you expect if the subduction process destroys more crust than that is created in the ridges?") and required participants to both write and draw.

8.3 Scoring

A rater scored all the tests unaware of the condition of each participant. Before doing so, approximately 30% of the tests were also scored by a second rater. Interrater agreement was .94 on the prior knowledge test, .82 on the retention test and .92 on the transfer test. Disagreements were solved by consensus.

A template with possible answers was developed for the prior knowledge, retention, and transfer tests. Each template included accurate, correct but incomplete and incorrect answers for each question. These answers yielded 2, 1 or 0 points, respectively. For example, an accurate answer for the question about mountains' formation in the prior knowledge test was one explaining that, for mountains to be formed, tectonic plates must collide and push each other. An accurate answer for the question about plates' collisions and movements in the retention test included explaining that plates move because they are floating on magma, which in turn is moving permanently due to the convection currents, and that plates collide because sometimes two moving plates converge. An accurate answer for the question about an increase in the process of crust destruction in the transfer test was one predicting crust to disappear so the mantle would be exposed to the environment. Total scores ranged from 0 to 16 in the prior knowledge test, from 0 to 12 points in the retention test, and from 0 to 20 in the transfer test.

8.4 Procedure

Participants were simultaneously in groups of approximately eight participants per session. Each participant was seated in front of his/her own computer. The presentation corresponding to either the prompted explanation or the rough explanation condition was already activated in each computer. This was done in order to randomly assign participants to the conditions.

First of all, participants received some basic instructions from the experimenter. “Thank you for participating in this experiment. We are interested in how people learn from multimedia instructional materials. You will be asked to study a computer-based multimedia presentation on plate tectonics. Please, pay attention to the presentation, as after watching it you will have to solve some questions. Before watching the presentation we want you to fill in a prior knowledge test.”

After receiving the instruction participants received the prior knowledge test. Solving this test took no more than 20 minutes.

When participants finished filling in this test they started watching the presentation. Time on task was equaled for all participants by predetermining the time of exposure for each slide in the presentation

(total duration was approximately 15 minutes). As explained before, in between the modules of the presentation instructional explanations were interjected. These were aimed at revising typical misunderstandings identified in prior studies. Participants in the prompted explanation condition were provided with explanations in combination with devices making the misunderstandings explicit (prompts). Participants in the rough explanation condition were provided with identical explanations except that they were not combined with prompts. The time that participants spent reading the instructional explanations was not fixed; instead, participants were free to spend the time they wanted on them. This time was recorded (in seconds) and analyzed as a dependent variable.

After watching the presentation participants were given the retention test. Solving this test took no more than 15 minutes.

Then the transfer test was delivered. Participants spent no more than 25 minutes on it. After this final test was collected, participants were seen off. Each session lasted about 75 minutes.

8.5 Results

Performances of the two conditions in all variables are shown in Table 1. Prior knowledge was analyzed first in order to ensure that all conditions had comparable levels in this variable. An independent samples *t*-test was used finding that there were no significant differences between the conditions, $t(25) = 1.20$, $p = .25$. This result indicates that participants in the two conditions exhibited similar levels of prior knowledge.

Table 1. Performances of all conditions in all variables.

	Prior knowledge		Retention		Transfer		Time on explanation 1		Time on explanation 2		Time on explanation 3	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Prompted explanation	8.00	6.28	6.85	2.27	8.46	2.93	12.62	5.62	21.38	8.44	42.85	18.17
Rough explanation	7.61	3.84	4.71	2.52	5.00	2.91	23.36	9.46	30.57	13.18	50.93	42.35

Note. Maximum scores were 16 for the prior knowledge test, 12 for the retention test and 20 for the transfer test. Time is measured in seconds.

Regarding the retention test, there were significant differences, as indicated by a *t*-test, $t(25) = 2.31$, $p = .03$. This indicates that participants receiving prompted explanations were more able to recall the key concepts covered in the presentation, as compared to those in the rough explanation condition. The size of this effect was large ($d = 0.89$).

With regard to the transfer test, there were significant differences between the conditions, $t(25) = 3.08$, $p = .005$. This means that participants in the condition with prompted explanations were more able to apply the knowledge they had acquired, with respect to their counterparts. The size of this effect was large ($d = 1.18$).

Participants in one and the other condition spent different time on the instructional explanations. More accurately, participants in the prompted explanation condition spent significantly less time reading the explanations than those in the rough explanation condition. This was true for the first explanation, $t(25) = -3.55$, $p = .002$; and also for the second one, $t(25) = -2.14$, $p = .04$. Sizes of these effects were large ($d = 1.38$ and $d = 0.83$, respectively). Differences in the third explanation did not reach significance, $t(25) = -0.64$, $p = .53$.

9 Discussion

Instructional explanations can be especially helpful when learners are stuck and cannot generate repairing inferences to overcome a problem of understanding. In spite of this potential advantage, very often instructional explanations have failed to promote learning. In this chapter (see also Wittwer & Renkl, 2008) we have suggested two possible explanations for such pattern of results. One interpretation is that explanations do not address the specific flaws in learners' understanding, which has been empirically supported by prior research (Nückles et al., 2005; Wittwer et al., 2008). Another interpretation is that, for explanations to work effectively, they have to be provided after learners' problems of understanding have been pointed out. Evidence coming from a prior study (VanLehn et al., 2003) is in line with this interpretation. Nevertheless, the results are somewhat inconclusive, as explained before. Accordingly, we conducted an experiment aimed at gathering support for the possibility that, if they are to be effective,

instructional explanations have to provided after the flaws in learners' understanding that they are intended to revise are identified.

The results revealed that participants in the condition with prompted explanations outperformed those in the condition with rough explanations. Specifically, the prompted explanation condition exhibited better performances in retention and transfer, as compared to the rough explanation condition. This represents empirical support for the second interpretation of explanations' failure that we suggested. In other words, an explanation for the ineffectiveness of instructional explanations is that they are not provided after the learners' misunderstandings have been pointed out.

An interesting result is that participants in the rough explanation condition spent significantly less time reading the instructional explanations inserted into the presentation, with respect to participants in the prompted explanation condition. This means that being aware of the misunderstandings that the explanations are intended to revise make learners not paying more attention to the explanations, but deeply exploiting them. Simply put, prompts make learners gain more spending less. Participants receiving instructional explanations in isolation are less able to see for what the explanations are provided, which makes them waste time with them without taking advantage.

The results of the present experiment extend prior work in two ways. First, they extend the findings in the study of VanLehn et al. (2003) by confirming that instructional explanations are more effective indeed when provided after learners have realized that there are flaws in their understanding. Second, our results extend those in the study of Sánchez et al. (2009) by replicating their findings. To the extent that the finding has been replicated in several experiments, it can be considered sound.

A theoretical implication of our results is that learners have to realize that there are specific flaws in their understanding in order to take advantage of instructional explanations. When this condition is met, then learners use instructional explanation as a basis for revising and repairing their flawed mental representations. In terms of the mental model repair view (Chi, 2000; deLeeuw & Chi, 2002), one might express this by saying that learners have to detect misunderstandings before being able to repair them.

Another implication of the results presented here is that the importance of the processes of detecting and repairing is stressed. As mentioned before, some models of self-regulated learning from instructional materials point out the processes of (a) monitoring our ongoing understanding to detect flaws and (b) regulating our understanding to repair the flaws as critical processes in deep learning (Chi, 2002; Hacker, 1998; Otero, 2002). Evidence coming from different lines of research confirms such assumption. More accurately, it has been found that the skills of detecting and repairing predict how well learners learn from instructional materials (Cain, Oakhill, & Bryant, 2004), good learners differ from poor learners in that the former detect and repair more than the latter (Azevedo, Guthrie, & Seibert, 2004) and training learners on the skills of detecting and repairing benefits learning (McNamara, 2004). Another form of demonstrating how critical these processes are in learning is to find that supporting them has an impact on learning. This is what we have done here: participants receiving support for the process of detecting and repairing (prompted explanation condition) outperformed those receiving support for the process of repairing (rough explanation condition).

A practical implication of the findings presented here is that, in order to be effective, instructional explanations have to be given after the misunderstandings they are intended to revise are identified. Based on our results, this might be taken as a guideline in designing different kinds of instructional explanations. This is to say, those explanations in the form of summaries at the end of a lesson in a textbook, elaborations in example-based instructional materials, tutors' clarifications in human tutoring sessions, feedback in computer-based learning environments or reformulations in teachers' classroom discourse should include devices making learners' problems of understanding explicit if they are to work effectively.

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Appendix A

The computer-based multimedia presentation consisted of modules comprising slides with static pictures and accompanying text. Figure 1 shows a screenshot of one of the slides (the text has been translated into English from the original).

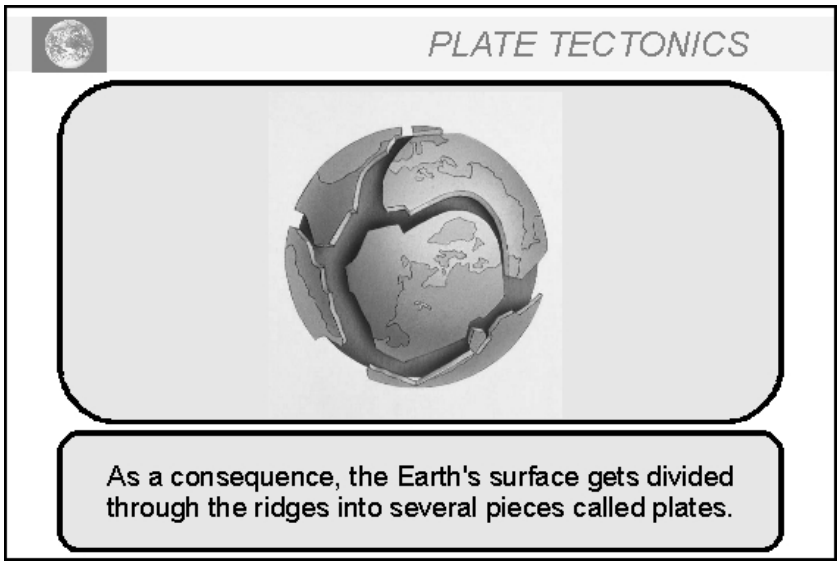


Figure 1. Screenshot of the multimedia presentation on plate tectonics.

Appendix B

The presentation included instructional explanations, which revised learners' common misunderstandings. Prompted explanations were preceded by devices making the misunderstandings explicit. Rough explanation were provided without prompts but preceded by a default sentence ("Concerning this module, there is something you should consider."). A complete transcription of one instructional explanation is this:

Prompted instructional explanation number 3 (translated into English from the original).
[Prompt]
After attending these modules, what you probably see is that in both the Andes and
the Himalayas two plates collide forming mountains. Although correct, this idea is not enough
to completely understand how plate collisions work. What you probably did not realize is that
collisions in the Andes and the Himalaya are very different, which is crucial for the understanding of the modules. Here you have an explanation going into these differences in depth.

[Instructional explanation]
In the Himalaya two continental plates are crashing, that is, plates with identical weight and size. Therefore, the collision is head on. Conversely, when one of the plates is oceanic, as in the Andes, plates have different weight and size. Because of that, the oceanic plate, which is heavier, sinks under the continental plate and melts in the mantle. Moreover, continental plates in the Himalaya push each other, thus, folding up and forming mountains without volcanoes. What happens in the Andes is that the sinking plate puts a lot of pressure on the continental plate, which lifts the continental plate and forms cracks in it through which magma from the mantle surfaces forming mountains with volcanoes.

ARE WEB-BASED LEARNING ENVIRONMENTS TRANSFORMING TERTIARY EDUCATION?

The case of a large humanities institution

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ABSTRACT

The paper presents a survey carried out at the Faculty of Arts in Ljubljana two years after the introduction of a web-based learning environment to support the delivery of its programs. As the approach to diffusion was based on optional-innovation decision, the aim of the research was to profile the use of the WBLE as well as to assess its impacts. The research consisted of two parallel online surveys (teachers and students). Despite some restrictions on the interpretation and generalization of the results, the research provided important insight for planning of future action. The spread of the innovation, driven by the typically profiled early-adopter teachers working with a population of digital natives, was rapid. However, closer analysis of what was going on in the virtual classrooms shows that the WBLE was so far mainly embraced as a tool for improving the flexibility of the educational process, while its positive effects on learning outcomes have yet to be proven. Initial concerns about infrastructural constraints as the main hindrance to the successful implementation of e-learning have now given way to the challenge of further training of teachers. This should enable them to more fully exploit the new tool, and thus actually transform the teaching/learning process in order to make a significant difference in terms of its outcomes.

KEY WORDS: Web-based learning environment (WBLE), E-learning, Tertiary education, Humanities, User survey

1 Background: The Faculty of Arts and the Process of Introducing a WBLE

Established in 1919, The Faculty of Arts in Ljubljana with its over 7,000 undergraduate students, several hundred postgraduate students, over 500 faculty and 25 departments covering disciplines ranging from geography to languages and music studies is one of the biggest members of the University of Ljubljana. As is fairly typical of similar institutions in Europe and worldwide, implementing change in such a context is a slow and complex process. This also holds true of the introduction of ICT into the teaching/learning process. Of course, specific online environments to support curriculum delivery were first implemented in Western tertiary education several decades ago. Nevertheless, the introduction of a WBLE at the Faculty of Arts in Ljubljana entirely fits the definition of curricular innovation as 'planned application of ends or means, new or different from those which exist currently in the classroom, school or system, and intended to improve effectiveness for the stakeholders' (Marsh 2004, p. 80).

Individual teachers at the Faculty of Arts began exploring the possibilities of web-based learning environments more than a decade ago, which gradually led to administratively supported action to implement the innovation at the level of the whole institution. This began taking place in 2005, following an all-faculty survey carried out to reveal the interests, attitudes and existing ICT expertise of teachers. After an introductory workshop for the management, the Faculty provided the initial technical and administrative conditions for the implementation of the chosen WBLE, Moodle, in all of its programmes.

However, due to the size and complexity of the institution, and also due to a relatively weak ICT infrastructure (not enough computers for all the students etc.) the Faculty could hardly use the same whole-scale approach to innovation as some other schools, where the management made the use of a WBLE mandatory for all instructors and students. Instead, we opted for a 'soft' approach, which is based on the recognition that a) teachers are the key to curricular change, and b) innovation is more likely to succeed when it is not forced. Drawing on the experiences of the University of Lugano in Switzerland (Buttori,

Cantoni, Tardini 2004), the teachers were informed about the availability of the WBLE, invited to introductory training workshops, and then allowed to freely choose whether or not, how and to what extent they wished to incorporate the new technology into their teaching. The workshops, attended in the first year by some 25 participants, and then by 65 more in the following two years, were geared at staff with little or no experience in using online environments, and thus focused on the basic skills and strategies an instructor needs to set up and use a virtual classroom. The WBLE was presented not as an environment which could replace face-to-face classes, but as a tool that could enhance and supplement regular university teaching.

This approach seems to have been successful in diffusing the innovation; despite infrastructural constraints, the use of the e-learning system grew enormously over the first two years, as seen in the graph below.

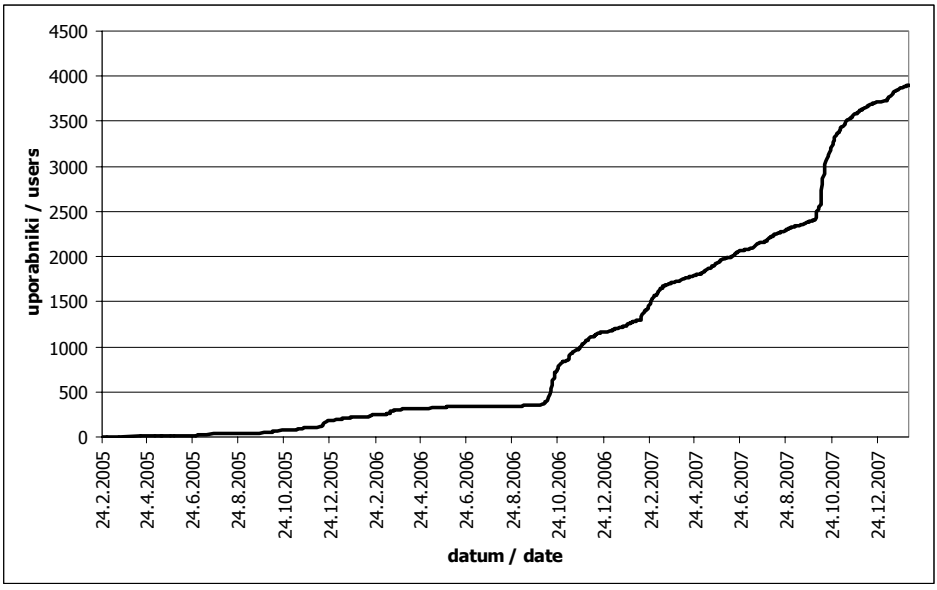


Figure 1. Growth of number of WBLE users at the Faculty of Arts Feb 2005 - Jan 2008 (Krevs 2008)

However, the relative popularity of a new tool does not in itself say anything about how the innovation is changing the teaching and learning process. Since the year of the introduction of WBLE coincided

with the concluding phase of the recent curricular reform of higher education in Slovenia (the Bologna process), it was hoped that the innovation would provide additional incentive for teachers to rethink their teaching methods. This goal was all the more significant if we consider the fact that more than a half of the undergraduate programmes at the Faculty of Arts lead to subject teacher certification. Pre-service teacher trainees who experience a new teaching approach may not only learn their course content better but also take with them into their teaching careers expanded views of the teaching and learning process. Considering the current growth of e-learning in public and private schools at all levels, to have experienced at least one WBLE-supported course is a must for future teachers of any subject today (cf. Resta 2002, pp. 32, 33).

2 Research

Due to the size and heterogeneity of the Faculty of Arts, evaluating any innovation at the level of the whole institution is a challenge, but all the more crucial for determining further action and policy. For this reason, several surveys were carried out from the first semester (trial implementation) onwards. The most comprehensive survey, presented in this paper, was carried out two years after the official introduction of e-learning. Its main aim was to evaluate the scope and the impact of the innovation in order to identify the strengths and weaknesses of its implementation and gain data to help plan further development.

Of course, some data on the scope of the innovation could be gained even by an incidental visitor of the Faculty e-learning website (http://e-ucenje.ff.uni-lj.si); at least the overall number of virtual classrooms and which departments and teachers were running them. Further data could be gained from the WBLE software databases (number of participants per virtual classroom, number of classrooms created but not used etc.), but that would still only be a part of the whole picture. For example, we did not know how many of the WBLE-supported courses were postgraduate/ undergraduate (because the WBLE could not be integrated with the Faculty's existing administrative support web portal), to what extent teachers used the WBLE to support their research projects etc. In addition, the main thrust of the survey was aimed at

finding out something that is beyond the reach of figures describing the scope of WBLE use alone: how the WBLE actually changed the teaching and learning process through the experiences and perceptions of its key agents.

The research was designed as a two-tiered electronic survey carried out through the SurveyMonkey website. One questionnaire was designed for the student body. An invitation was sent out via the WBLE to all of the users who were registered as students in 2008 (a small number of those users were non-students such as members of the public or teachers registered as students). A separate questionnaire was designed for the teachers, and was sent out via the in-house staff mailing list rather than through the WBLE so as to reach not only those teachers who had begun to use the WBLE but the potential users as well. In October 2008 there were 4,829 active registered student users, of which 210 responded to the survey (the teachers were not asked to require or encourage the students to respond to the survey, and the response rate was thus lower than was hoped for). Of the 318 teachers who were invited to participate in the survey, 37 responded (the response rate here was higher, but still relatively low, which can perhaps be explained by the fact that teachers of humanities seem to be particularly reluctant to embrace innovations involving ICT).

The survey design took into consideration that the teachers and students will provide two complementary perspectives on the same phenomenon. For this reason, the two questionnaires, while different to some extent, had the same overall structure with the following sections:

1. **Basic data:** Faculty department and status, gender, previous experience with WBLE (for teachers, this section was expanded

2. **WBLE use:** the number of virtual courses used by each participant, frequency and type of activity pursued in each course, estimates of time spent using the WBLE

3. **Expectations and satisfaction regarding WBLE use**: expectations the students and teachers held prior to introduction of WBLE, attitudes, perspectives on gains and problems

4. **Technical support:** the extent to which the existing ICT infrastructure (including the technical support service) available to teachers and students hindered or promoted the use of the WBLE

Both surveys included Likert-scale and multiple-choice items, the letter mostly with an open-ended answer option.

3 Results and discussion

Because of the fact that the research presented consisted of two parallel surveys which were intended to mirror each other to some extent, the results will also be presented in a parallel manner, in the form of simple descriptive statistics and their interpretation.

3.1 User profiles

What data did the survey provide about the early-adopter teachers and the first generations of student users? Let's have a look at the teachers first.

Of the 37 respondents 32 % had used a WBLE before, 51 % had used other ICT technologies, but not WBLE, while 17 % had not used any ICT to support their teaching. 43 % of the respondents were introducing the WBLE into their coursework in the current academic year, about the same percentage was getting acquainted with it and planning to gradually introduce it, and 19 % knew about the WBLE, but were not going to use it. A comparison of the total number of participants of introductory training workshops in the first two years (about 80), the total number of survey respondents (37) and the percentage of respondents who were using the WBLE in 2007/2008 (11), clearly shows that teachers needed a lot of encouragement and support. We should also note that those who responded to the survey were probably the more ICT-savvy among the teaching staff, and also among the more open to change and more interested in improving their teaching in general. The respondents who were not using the WBLE yet and were asked why and under what conditions they would do so, mostly mentioned training and technical support, e. g. *'I will use it if I am informed about training workshops, if I attend them and an expert explains to*

me very well, how a virtual classroom works and how to use it'.

In terms of their academic status, the majority of respondents were teaching assistants, 'docent' or language teachers, while only a handful were associate and full professors. The average number of years of teaching experience was 11,7. It seems that younger teachers and those in charge of courses where more interaction with students is expected (tutorials as opposed to lectures) were the first to embrace e-learning, which is not surprising.

The structure of the user body in terms of different programmes /departments at the Faculty as seen from the survey is consistent with that seen from the WBLE system database. The number of users per department was extremely varied; most student respondents were in departments where the chairs decided to take a more systematic approach to innovation (e. g. hired a trainer and required all their staff to attend). Such departments were Geography, Library and Information Science and English. In those departments, the system database and survey both showed large numbers of active student users. The survey also showed that a quarter of the departments had not really begun using the WBLE, although individual teachers had created virtual classrooms; not a single teacher or student from those departments answered the survey.

What about the students? Each responding student was enrolled in an average of 5 virtual classrooms (those who only experienced this form of teaching from one or two of their teachers, or none, seem not to have responded to the survey). However, this does not say anything about the scope of the activities going on in the WBLE. The average number of virtual classrooms they entered regularly every week was 3,5. (Most study programmes consist of 10 courses each year.) A separate question about the frequency of use of WBLE revealed that 49 % of the students enter the system as needed or when the teacher requires it, 32 % said they entered 1– 2x weekly, and only 13% used the system every day. Teachers, too, stated that they used the WBLE in 3,4 of their courses on average, but they seem to use the system more frequently than students: two thirds stated that they visited their virtual classrooms on a daily basis or even several times a day. This probably reflects two facts: a) many of the teacher users were only beginning to use the WBLE, and b)

the WBLE tends to be more work for the teacher in the typical initial phase where not a lot of complex interactive activities are used to which the students have to participate more heavily.

Further questions about the profile of the student users revealed that mostly they were in their 2nd, 3rd or 4th year of study. It seems that teachers chose to implement the innovation with the senior students first, expecting that it will be easier to handle for those students than for freshers who are dealing with a lot of novelty and disorientation as it is. 87 % of the students had not encountered a WBLE before, only a minority had done so at their secondary school or another university.

3.2 Details of use

The central part of the survey was aimed at revealing the scope and profile of the specific activities pursued in the WBLE by teachers and students. Individual teachers have complete overviews of their students' activities with the help of features such as 'Report', 'Statistics' and 'Journal', but obtaining and analysing such reports from all of the teacher users for all their courses would be too demanding. For this reason the survey included questions about both the time spent working in WBLE and the types of activities pursued.

Time spent in WBLE

The first question for the students was about the amount of time they spend using a computer for study purposes. Most respondents estimated this time to be 4-8 hours weekly. The next most frequent answers were 2-4 and 8-12. Has the students' time spent using a computer for study purposes changed since the introduction of the WBLE and to what extent? For almost a half of the student respondents this time had '*increased somewhat*', 47 % chose '*not increased*', and only 4 % said that it had increased a lot. These results suggest that for the students the computer is one of the key study tools and had been that before the introduction of the WBLE as well. But we have to consider the fact that it was probably the more computer-savvy and motivated students who responded to the survey in the first place, and it is logical that those students had no difficulty embracing the WBLE. This is further confirmed if we look at the responses to the question of how easy they find the WBLE to navigate (67 % chose the response '*I can find*

everything easily.').

The teachers' answers to the same questions were quite different. Only 22 % said that the time they spend working with the computer had not changed since the introduction of the WBLE. 33 % said this time had increased by 2-6 hours a week, while the rest estimated the increase to be 6-8 or over 10 hours a week. It seems that in the first two years, the introduction of a WBLE demanded a bigger investment of time and energy from the teachers than from the students.

Types of materials used in WBLE

This was one of the key sections of the survey from the point of view of the WBLE being a platform for a potential deeper change in pedagogy. The prevalent formats of materials published by the teachers in the virtual classrooms were Word documents and Power Point Presentations (92 % and 73 %), followed by links to webpages (49%), and only a negligible number of graphics, audio and video files. This shows that in the first years of the WBLE at the Faculty of Arts teachers had largely not yet begun to exploit the technical potential of the platform, even though the easy incorporation of multimedia materials is of the main advantages of a WBLE over traditional classroom teaching. Perhaps one of the reasons is revealed in the answer of one of the teachers to the question '*Under what conditions would you begin to use the WBLE if you are not using it already?*' The answer was '*if there was a bank of materials available*'. Of course, such banks will rarely exist, in particular for tertiary courses, which tend to cover very specific content. Materials usually have to be prepared by the teachers themselves, and this may be considerably more challenging in the case of multimedia materials. Also, the use of multimedia materials may require a certain reconceptualization of the teaching / learning process.

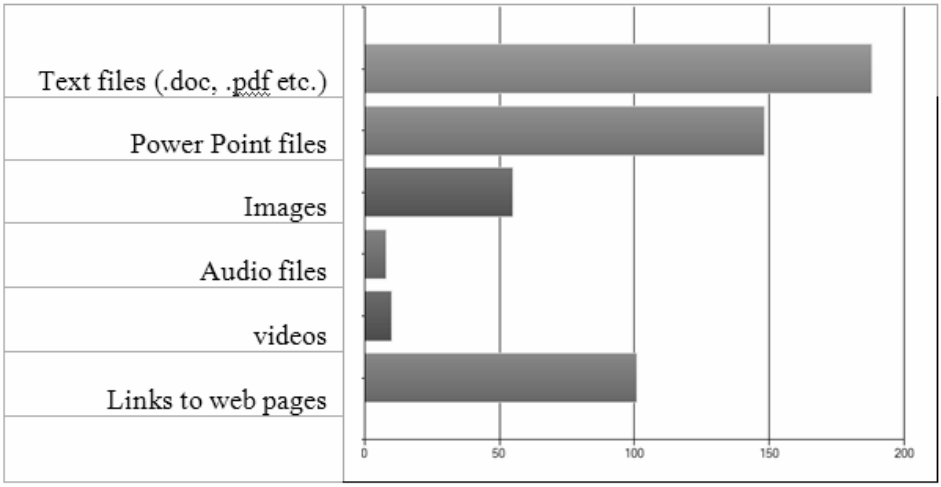


Figure 2. Frequency of use of different types/formats of materials in the WBLE (students' responses)

Types of activities

A further set of questions that aimed to reveal to what extent the WBLE was transforming the teaching /learning process was directed at the students. How many times since they began to use the WBLE had they posted their work (a file of any type) in a virtual classroom? (The results, of course, would be indicative of the types of assignments given /WBLE modules used by the teachers.) Only 22% of the students answered '*more than 10 times*' or '*I do it almost every week of the semester*' (6 %). As many as 50 % said '*1- 5 times*', and 22 % said '*I have never done it*'. Considering the fact that most of the respondents had been using the WBLE for at least two semesters, we can conclude that there was fairly little sharing of student work (with either the teacher or classmates) through the WBLE. Surprisingly, the structure of responses was very similar with the question about sharing small contributions: '*How many times have you participated in a forum in a virtual classroom?'* 50 % said they had never done it, 40 % had done it 1 – 5 times (over two to four semesters), and only 10 % said they had done it often. The next question further aimed to reveal how active and autonomous students were in using the WBLE. As many as 65 % stated that they had never done anything in a virtual classroom unless required by the teacher; they had not used the opportunity to, for example, ask a question, post a contribution to a

forum without being required to or contact the teacher or a classmate.

Which types of activities were then predominantly used in the virtual classrooms of the Faculty of Arts in their first two years? According to students, these were Assignment, Calendar and Forum. The responses of the teachers are consistent with this: Forum convincingly topped the list, followed by Assignment. Modules which support more complex activities and are more interactive were used very rarely / only by a few of the teachers (e. g. Quiz, Workshop, Dictionary). We have to note here, however, that teachers found the WBLE useful for some purposes which did not directly support the teaching / learning process (for example, the Wiki module for exam, tutorial or paper topic sign-ups.) It seems also important to note that this was one of the most often skipped questions in the teacher survey.

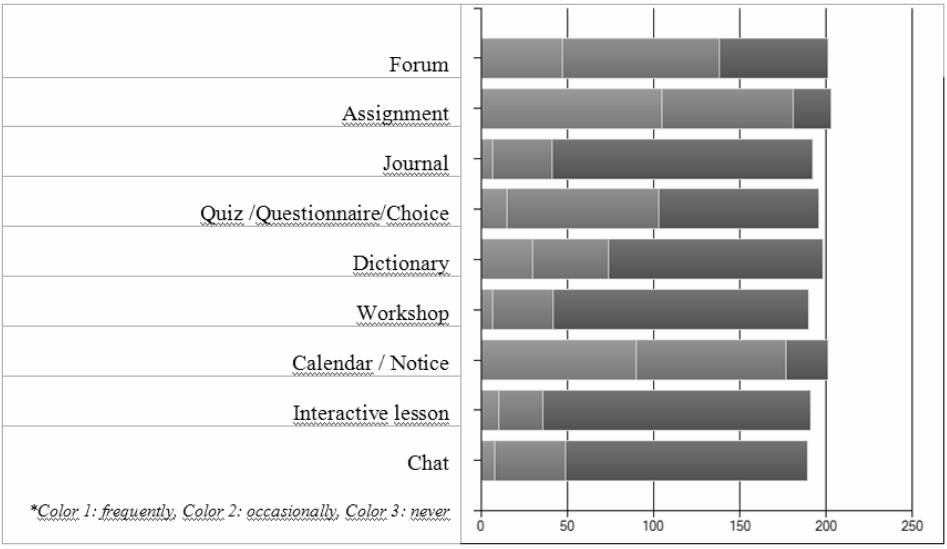


Figure 3. Frequency of use of different modules / types of activities in the WBLE (students' responses)

Impact assessment

What were the effects of the introduction of a WBLE as perceived by students and teachers?

Both were provided a list of advantages and disadvantages of the introduction of e-learning. Students prioritized the positive effects as

follows:

- easy access to materials
- being better informed about everything concerning a certain course
- flexibility of coursework ('*I can work whenever I have the time, whenever I feel like it, whenever I can*', '*I can do things from home and do not have to go to the university*').

Only a very small percentage of student respondents found the introduction of a WBLE good because it made them learn computer skills or because they could communicate with the teacher and classmates virtually.

The teachers' list of perceived advantages was very similar in its top half:

- students can turn in their work online and this work can be stored
- students can easily be sent notices
- virtual classrooms are available 24 hours a day every day of the year
- using e-learning reduces costs (less driving to work and less printing of materials)
- more interaction with students
- excellent overview of student activity
- development of the teacher's ICT skills.

What were the teachers' expectations prior to the introduction of e-learning and to what extent were they met?

Overall, e-learning seems to have delivered the expected effects to a mixed degree. The clearest finding is that the majority of teachers' work became more flexible, as had been expected. In terms of learning outcomes, 80 % of the teachers said that the exam grades had become higher or slightly higher on average, but at the same time 50 % said that students' knowledge was only partially better than before. These results would definitely require and deserve further exploration. The answers to the question about students' study habits were very mixed. One of the teachers said: '*I am disappointed by the attitude of the students; I have tried very hard to motivate them in the virtual classrooms and invested a lot of effort into materials, but they do not respond.*' This is surely an experience that

every tertiary teacher today has had at some point, regardless of whether we are using a WBLE or not. Perhaps some teachers had too high expectations of something that is merely a tool, or the tool was not used in an effective manner.

What were the effects of e-learning on outcomes as perceived by the students?

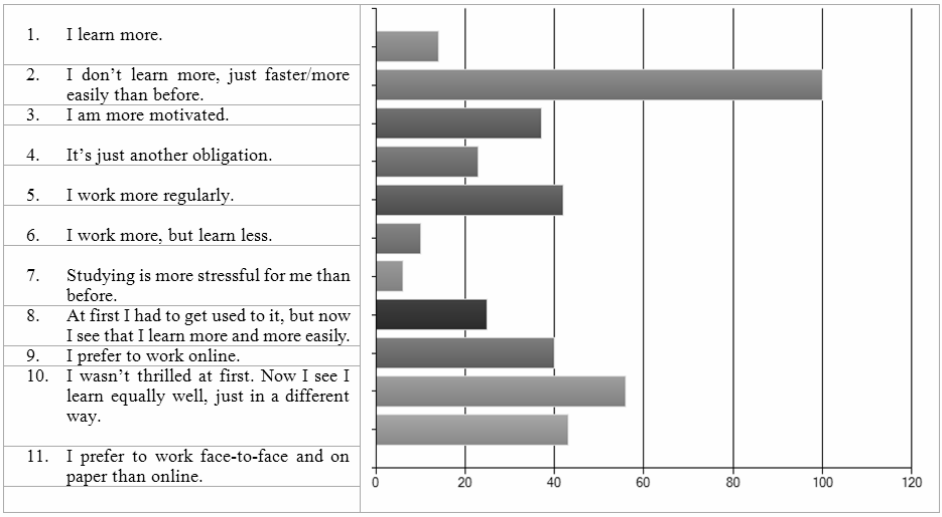


Figure 4. The effects of the use of WBLE on the learning process & outcomes (students' responses)

As seen from the graph above, the majority of respondents estimates that e-learning does not affect the quantity or quality of their learning outcomes (statements No. 2 and 10), but it improves the efficiency of the process (No. 2) or merely changes the pathways (No. 10). Nos. 1, 3, 5 and 8 indicate a smaller, but still fair percentage of students who feel that e-learning has increased their motivation, the quantity or the quality of their learning. Only a very small percentage of students felt that the use of a WBLE affected their learning in a negative way (Nos. 6 and 7). The two statements about students' preferences (Nos. 9 and 11) divided the respondents in half, which probably testifies to the fact that the appeal of e-learning generally depends on various learner characteristics such as personality and learning style.

3.4 Problems, obstacles and general issues

What were the main problems and obstacles to successful use of e-learning from the students' and teachers' perspectives?

The students' list of problems most frequently rated as '*big or fairly big problem*' (each problem could be chosen more than once) was as follows:

- too many limitations in the WBLE (e. g. who can upload what and when): 77 %
- not every student has good enough computer skills (77%)
- technical problems (65 %)
- reduced F-2-F contact with the teacher and classmates (63)
- not enough help and support (60 %)

There were also quite a lot of open-ended answers to this question, which mostly talked about the lacking infrastructure and support, and critiqued the teachers' ways of using the WBLE (e.g. '*I only have access to internet in the library, which has a time limit*', '*when something doesn't work, it is hard to get the teacher to understand, that it isn't working*'.)

For the teachers, the list of problems was:

- time-consuming preparation of digital materials (90 %)
- quality of internet access and ICT equipment (80 %)
- organizational problems (70 %)
- fear of technology (40 %)
- reduction of personal contact with students (30%)

The open-ended answers to this question were few but provided interesting insights. Some teachers, for example, were bothered by the fact that e-learning had not officially been incorporated into the curricula and regulations. Another problem was, as expressed by one teacher: '*I did not know what the students' ICT situation (skills, access) was, so I overestimated their workload that resulted from my e-assignments.*'

To what extent was the successful implementation of e-learning hindered by lacking infrastructure?

Since it was clear from the beginning that the Faculty of Arts does not have the ideal infrastructure for implementation of e-learning, one of the aims of the survey was to find out to what extent the technical aspects actually hindered the use of the system in practice. It turned out,

however, that this was not a major issue. Teachers, without exception, reported to be using their home computers for accessing the WBLE, where they have either DSL or cable internet. They claimed to have encountered technical problems such as too slow internet connection or software/hardware breakdowns very rarely. Students, too, had few technical obstacles to using the WBLE as 68 % reported using a home computer / computer in the dorms, over a third own a laptop, and the Faculty of Arts offers wireless internet access. As for the technical support service (an employee of the ICT center at the Faculty of Arts whose main job has been to support the e-learning project), this was much more exploited by the teachers than by the students.

How successful was the approach adopted to user training and introduction of the WBLE to teachers and learners?

49 % of the teacher respondents had taken the initial training course and over 80 % expressed the wish to attend a further training course. The open-ended question designed to elicit teachers' training needs showed that some teachers would prefer an online course in using Moodle or individual training, and some said they lacked the time for this extra engagement or were not informed enough. Students were also asked about training/introduction to e-learning both for them and the teachers. 39 % of the students felt that for them, a short introduction and technical instructions provided in class sufficed, but they stressed that it should not be theoretical only - the teachers should demonstrate the virtual classroom on LCD. 91 % of the students agreed that it was not necessary to organize introductory workshops or WBLE trials for them. 30 % of the students felt that their teachers had not provided sufficient introduction to the WBLE. As for the initiation of teachers into e-learning, half of the students felt that training in the use of a WBLE should be obligatory, and the other half that it was not crucial, but would help the teachers to be more effective.

How did the students see the teacher as a user of the WBLE?

The students were asked to what extent, in their opinion, the use of a WBLE depends on an individual teacher. As expected, most agreed that the quality of e-learning will greatly depend on how an individual teacher approaches it, but, surprisingly, quite a few students thought

that the teacher's ICT skills are more crucial to this than their primary teaching competences.

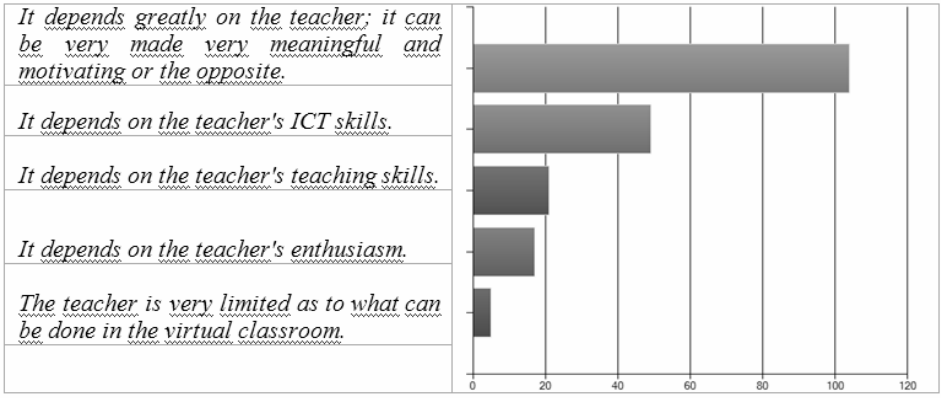


Figure 5. The students' perceptions of the teacher's new role as e-teacher

An additional question for the students that also referred to how the teachers used the WBLE was about the layout / graphics of the virtual classrooms and what improvements they would like in that area. As many as 67 % said that they would like information / materials to be more clearly laid out, and 31 % would like better graphics (bigger fonts, more images and colors).

The last questions in the survey directed to both students and teachers inquired about their attitudes towards e-learning in general and their perceptions of the attitudes of the other participants and stakeholders. The teachers rated their own attitude as 'in favour of e-learning' to 'enthusiastic', the attitudes of their colleagues and the students mostly as 'in favour' (not 'enthusiastic'), but they answered 'not sure' about the attitudes of the management and the university. The students answered a similar question, rating the attitudes of all stakeholders mostly as 'in favour of e-learning'. 49 % of them felt that the introduction of e-learning at the Faculty of Arts was 'nothing special, normal for these times', and 32 % agreed with the statement that 'it was about time; other places have had e-learning for quite a while'. 17 % felt that e-learning was a very good thing, only the ICT infrastructure at the Faculty of Arts was insufficient. Students also agreed (94%) that e-learning is best used in combination with face-to-face instruction and can not replace it. As

many as 60 % said they would like every course in their program to be supported in the WBLE (so far, this has not been the case for any program at the Faculty of Arts). 26 % said they did not care, and only 16 % were against this idea.

4 Conclusions

The research presented in this paper aimed at evaluating the scope and impact of the introduction of a WBLE at the Faculty of Arts in Ljubljana. As recommended by Donert (2003), the focus was not primarily on the negative aspects / limitations, but on the positive impact and indications of a 'significant difference' in terms of the quality of educational processes and outcomes. The online format of the survey was appropriate for the research population of users of e-learning, and the sample is not small, but the low response rate (4 % students, 11,6 % teachers) seems to indicate considerable self-selection. The soft approach to innovation diffusion that the Faculty of Arts chose to adopt was successful in that with a relatively small investment the WBLE began to be used by over 50 % of the institution's large student body and teaching staff in its first two years. However, the survey results show that for many of them this was merely 'scratching the surface' and that the initial implementation phase may have been the smaller challenge than what should follow.

The early-adopter teachers were mostly younger staff in charge of seminar courses with prior ICT experience and motivation to attend basic training in the use of the chosen WBLE. Almost invariably, they chose to introduce e-learning into their courses taught to at least 2nd year students or older. The student users of e-learning as portrayed by the survey were clearly digital natives who required no training for e-learning, had few technical problems with it and considered its introduction a natural step forward for their institution. A crucial finding of the research is that the types of activities used in the first two years of the WBLE implementation were not very complex or interactive despite the range of such options available. In terms of the types of materials used, too, the teachers seem to have merely transferred the existent, fairly traditional teaching/learning paradigm into a new environment. The WBLE was mostly used as a tool for making materials

and information available to students, collecting their work and generally the administrative management of a course. Students, too, saw the new flexibility of the teaching/learning process as the main advantage of the introduction of e-learning. As for the effect of the innovation on the learning outcomes, both groups of stakeholders estimate this to be positive overall, although the results here were quite mixed and would definitely require further investigation.

It is interesting to note that the initial concerns of the institution were primarily in the technical area, but the survey results suggest that the technical infrastructure was not a major issue at all. A major challenge for further development arises from the realization that the availability of the new tool and the basic skills needed to handle it in themselves do not affect the deeper aspects of the teaching/learning such as the role of the teacher and student, methodology, motivation and autonomy. This, of course, is not a matter of any tool, no matter how complex, but requires a change of paradigm which can only be slow and brought about through considerable long-term investment. The next challenge for the Faculty of Arts is definitely, as Singh, O'Donoghue and Whorton (2005) would agree, to provide further well-designed teacher training in ICT skills, group and individual facilitation and integration of online and face-to-face learning.

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LEARNING THROUGH PHOTOGRAPHY IN SOCIAL SCIENCE FROM THE THIRD TO THE FIFTH GRADE

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1 Background

We live in the era of computers and verbal communication is more and more complemented with, often even substituted with visual communications. Mirzoeff (1998; cited in Avgerinou 2009) believes that postmodern culture should be represented in images and understood visually, like the 19th century is classically represented by the written word, for example newspapers and novels. »For the majority of people, however, being constantly bombarded by images does not necessary lead to a conscious recognition of this phenomenon." (p. 28), and this is especially true of children. Pictures are usually perceived in a passive way, visual literacy is not well developed. Visual messages are not dealt with in a critical way, "we have difficulties recognising different functions of images, we do not distinguish really important images from the invented ones, glamorous, pseudo-sophisticated« (Avgerinou 2009, p. 29).
When teaching geography and history, moving and still images are frequently the main source of data and we use them to illustrate and complement written and oral explanations. The percentage of picture material in school-books is growing (Umek, 2008) and most of e-learning material is based on visuals.

The modern ICT provides multimedia environments. Many pupils have access to the internet, to information in different forms, but not all of them. Unfortunately, the digital divide in Slovenia is not decreasing; in the sense of absolute differences it is even increasing (Dolničar and others 2002). We believe that the differences between pupils in their

knowledge, ICT skills, access to information, connection in web communities and exchange of information are increasing. It is the task of schools to offer pupils the relevant knowledge and give them an equal headstart in life.

Like pupils, teachers, too, encounter modern technology in their everyday lives and develop ICT skills mostly informally. One such skill that has become very wide-spread over the recent years is using digital photography. Almost all new cellphones are equpipped with cameras, and standalone cameras are now primarily digital. Due to this, pictures are now not only being consumed but also created and used for communication more than that was the case in the past.

The expansion of visual images was caused by the digitalization of the image and that is why visual literacy is now defined as digital visual literacy. According to Dam (2008; cited in Avgerinou 2009) digital visual literacy entails the capability to:

- Create and understand computer-generated visual information,
- Critically evaluate digital visual material (two- and three-dimensional, static and moving)
- Make decisions on the basis of digital visual representations of data and ideas.

The educational / instructional significance of the image was frequently studied in the previous century. Numerous researches confirmed that the image, more than the text, attracts the attention of pupils, helps with storing knowledge in memory and describes reality much better as words. Hempe (1999; cited in Bijnens and others 2006, 8) claims that today, in the world of images, we must pay attention to the power of images: "…visual demonstration, dramatization, presenting visual evidence, and making an emotional appeal. Images always carry hidden or semi-hidden messages such as narrative, emotion, authority, authenticity and symbolism". The benefits of making pupils visually literate include improvement of verbal skills, self-expression, motivation, self-image and relationship to the world, self-reliance, independence, and confidence (Flynt and Brozo 2010, p.528).

If Dale (1962; ibid) believed in the previous century that images can help reduce the excessive verbalisation that characterizes school instruction,

now the question arises whether the reverse process is taking place and in many cases large quantities of image material dominate verbal communication.

Bijnens and others (2006) who in their *'Handbook on Digital Video and Audio in Education'*elaborated in detail the use of digital film and audio during lessons and much can be applied to the use of photography during lessons. A photograph can be used for achieving different objectives: as illustration of the content, as representation of objects or events that cannot be otherwise presented in the classroom, for analysis, in a series to demonstrate a process or give visual instructions, for documentation, as a prompt, for integration with other media (adding text, audio, dynamic demonstration of static images…). Preparation of multimedia materials on the basis of photography enables a combination of different learning techniques and learning sources, which has many advantages for learning because audiovisually supported information is generally better understood and memorized.

Digital technology makes it possible to develop both sides of literacy, receptive and productive (decoding and encoding), as has always been possible with other types of literacy. When learning with photographs, the imbalance between the two aspects is huge, but it is very important to develop both. That can be confirmed on the example of cartographic literacy, which is one of the forms of graphic and visual literacy, where research shows that making maps is more efficient for the development of understanding maps than the reading of maps (Umek, 2003).

Learning by taking and showing digital photos means learning ICT and learning visual literacy, which have been identified as essential aspects of literacy by the USA Partnership for 21st Century Skills[10] (Avgerinou, 2009). The current perception of what learning is and of what it should be is also changing as more teachers integrate ICT in their lessons (Flynt and Brozo, 2010). In Slovenia visual literacy is still neglected (it is scarcely mentioned in the curricula), and ICT is gradually entering the

[10] The Partnership for 21st Century Skills is a USA national organization that advocates 21st century readiness for every student.

classrooms. The main role of the research presented in this paper is to promote learning with digital photography and integration of ICT into content lessons in primary grades.

2 Purpose of research

In the research we concentrated on the use of a digital camera, emphasising photography and working with photographs in social science classes in elementary school. Learning with the images and demonstration as a teaching method are of great importance for development of concepts and understanding of geographical and historical processes, especially with topics that are distant in time and space. At the same time, pupils still build knowledge on experience on what they bring from their home environment, which is the ideal combination for the use of photography in both roles, as the source of knowledge and as the representation of knowledge. That is why we introduced the innovative project *Taking photographs during lessons* into the third, the fourth and the fifth grade of elementary school. Also the pupils at this age have already developed the necessary skills for using the camera and computer.

For participation in the project, good ICT equipment of the classroom was not relevant, as we were interested in how efficiently the use of digital photography and computer could be introduced in any given conditions and which problems the teachers have to deal with. The starting point of our project was the knowledge of teachers. We assumed that the teachers will not have many difficulties when connecting photography with the learning content and that they have enough ICT knowledge to be successful in the project. We also hypothesized a constructivist approach to the lessons which requires new technology as the transmission role of the teacher is not possible anymore.

Working with different devices usually motivates pupils. We were also interested in what knowledge the pupils will obtain through the use of photography (production of photographs on the computer and presentation of their products) and if the cooperative learning method employed will have a significant impact in view of the differences in preliminary knowledge between individuals.

One of the main purposes of the project was to promote learning with photography and to establish the key obstacles to wider use of the photography as a learning method. The research questions were as follows:

- How different ICT equipment in classrooms influences the integration of learning with photography;
- What knowledge is required from the teachers for integration of learning with photography;
- What organizational processes the teachers will use (equipment needed, preparation time, implementation of photography, uploading to the computer, preparation of the projection …);
- How the teachers will integrate learning with photography into the learning process;
- Which learning objectives can be targeted when integrating learning with photography;
- Which are the advantages, limitations and disadvantages of this learning method;
- How the teachers will feel about learning with photography when concluding the project;
- Does taking photos and working with ICT stimulate cooperative learning;
- How will the pupils feel about learning with photography when concluding the project.

3 Method

In the project »Learning social science with photography« (hereinafter 'the project'), six teachers from four schools collaborated. The research methodology adopted was that of action research. After having determined the objectives, the desired instructional changes and the action hypotheses, we made the action plan. The plan included two action circles. The first one was carried out in the school year 2008-2009, the second one in the school year 2009-2010. Mid-point evaluation was done by means of qualitative analysis of lesson plans and reports, the products of pupils and an interview with the participating teachers. The evaluation at the conclusion of the project included the analysis of lesson plans and reports, pupils' products and a written survey of all the pupils

and teachers. We compiled the questionnaires ourselves and asked for revisions from a research methodologist and the participating teachers prior to administering it.

In the school year 2008-2009, in spring, the project was carried out in three 5th grade and two 4th grade elementary school classes. In the first circle of the research every teacher prepared one learning unit with integration of photography into the lessons. Before the project the pupils did not take photos in the lessons or work with PowerPoint. The latter was used only by the teachers. During the project the participating teachers had free choice in selecting topics, learning objectives, forms of lessons etc. In June 2009 the first experience cycle was evaluated. In August we planned work for the following school year. All of the teachers decided to continue the project.

In the second cycle of the research, in the school year 2009-2010, another teacher joined the project. She had a lot of experience with using a camera in the lessons, but until then she had been the one taking the photos, not the pupils. The aims of the second cycle in all classes were to carry out three learning units with the integration of photography into the lessons.

In both cycles of the project the teachers carried out 19 lessons in which the pupils took photos. The pupils of the fourth and fifth grade transmitted the photos to the computer, then into PowerPoint and made presentations of their photographs with the text added. The pupils of the third grades were working with printed photographs.

4 What we learned

4.1 Learning objectives and topic selection

The participating teachers wrote 96 learning objectives in their lesson plans within the project. Half of the objectives were from the field of content knowledge, half was functional knowledge. In teachers' own evaluations, they have achieved the desired objectives.

The teachers saw the most potential for the use of photography in

geography lessons and sociology lessons, none of them included history lessons. For geography topics pupils searched for appropriate scenes in the environment, taking into consideration the aims of the task, and for sociological topics they photographed scenes in which they posed themselves. In the first case they learned how to observe and recognize objective reality, in the second case they learned how to express and recognize the appropriate moment for photography. Taking photographs of the school, of nice, pleasant and ugly objects expressed the relation of the pupils to school space. The open-ended tasks gave pupils an opportunity for creativity.

Among the objectives connected with the use of technology, the most frequently set (14-times) objective was "pupils learn how to use a digital camera" which is understandable considering the title of the project. The following two objectives can be classified as visual literacy, and were only set by the teacher who has been taking photographs during lessons for many years: pupils know how to choose and take photographs of the elements, pupils realize that a photograph can show something different from reality. Fourteen objectives include the transfer of the photographs to the computer, the editing of the photographs, the transfer of the photographs to PowerPoint and working with the programme. Considering the domination of groupwork we expected that some objectives would expose the progress of pupils in social skills and peer learning.

4.2 Learning efficiency

In most of the teaching units, the content of the photography was the means of learning. Through taking photos, editing them on computer, adding captions and oral presentation, pupils consolidated the learning content. According to the teachers, pupils understood some concepts better in this way, especially more demanding ones. In three cases, the principal objective of the photography was for pupils to express their opinion about their school through the photos. Once, the product of a group of pupils was used to check the knowledge of the whole class. From the point of view of the achievement of content objectives, teacher claimed that learning with photography is not economical, but it offers a better quality of knowledge. When using ICT, we build new, transferrable knowledge. It has to be emphasised that such learning

requires a project approach with independent and collaborative learner activity.

The products of pupils were better in those classes where they had more freedom when taking photographs and when working with photographs on computers. For quality photographs, more basic knowledge and visual communication was required. Learning with photography is a complex learning activity to which different activities can be related and the pupils can develop different skills.

Through photography pupils learned how to observe. In half of the activities the pupils paid more attention to their environment and their observations were more focused. When choosing the motives, they used their knowledge and their point of view towards the object so they obtained new visual presentations. They oriented themselves in space and used maps. In the other half of the units they presented content adding text to the photographs. Pupils had many difficulties verbalising the topics, their oral presentations were much better. Many activities could not be executed individually, so groupwork was employed.

4.3 Integration of learning with photography into lessons

There were major differences between the teachers in terms of how they approached integrating photography into their lessons, and none of them changed their approach during the project. Only the teacher who had worked with a camera almost daily for three years was able to carry out all the activities (eight) within the regular class time. The other teachers, except for one who adapted the class schedule, the teachers used photography within special activities days (5 cases), additional lessons (3 cases), and four teachers set voluntary homework that the pupils presented in regular lessons.

For the run-in learning with photography and work with printed photographs two lessons were enough to cover one learning unit. When pupils worked with photography on the computer, used the PowerPoint programme, added text to the photos and presented the product to other pupils, at least five lessons were necessary. Shorter projects, carried out in two parts, took 5-7 lessons, and longer ones lasted for a month or two (8-10 lessons).

The reasons why photography was not integrated into the regular class time were that such work requires more time, a computer room needed to be booked, and teachers treated the project as additional work for which there is no time during regular lessons.

One of the obstacles for the integration of the photography into the lessons, was the run-in educational class system – structured according to hours, depending on learning themes, planned in advance, depending on school books, where every activity, which does not fit into the time schedule, cannot be integrated into the lessons.

4.4 Learning forms, technology used, obstacles

Working with photography was most frequently executed in groupwork format (10 times) – with one camera for each group, twice in pairs and twice frontally, five times individually, and four times as homework. It was evident that a small number of cameras available at the school are a limitation. Mostly the teachers worked with one camera, only five times the pupils brought their cameras to school.

There was a similar problem with the transfer of photographs to the computer. Eleven times it was done by the teachers, six times by the pupils at school. In two classes learners brought their laptops to school so the work could take place in their usual classroom, in other classes a part of the process took place in a computer room. The teachers emphasised that computer rooms are usually overbooked, which made the work more difficult, especially with activities which took place for a longer period of time. The equipment of classrooms with the interactive board did not influence the work on the project.

The most optimal solution for working with a digital camera and computer would be for each teacher to have at their disposal at least 10 laptops, at least one camera (available all the time), and 10 cameras for temporary use. Technical help would be very welcome even though the teachers thought they had enough knowledge to carry out that work by themselves.

4.5 Teachers' end-of-project evaluations

Four teachers thought that using photography in class is an efficient way of learning, one thought this is only a way or increasing variety in a lesson, and one thought the method was not appropriate for all pupils. All of them emphasised the motivation of pupils for such learning. They stated the following advantages of learning with photography:

- Better memorization of learning content, more permanent knowledge;
- pupils find it easier to learn more abstract notions (e. g. economic activities, natural characteristics of the landscape);
- more critical observation of the environment and more attention to changes, characteristics of the environment.
- Stimulation to think and not only to receive of information.
- Stimulation for independent learning.
- Sense of accomplishment because of the product, the presentation is attractive to listeners, they ask more questions.
- The photographs are very useful when consolidating and checking knowledge,
- Developing various skills: non-verbal expression – demonstration of events, processes with movements, verbal expression – explanation of photographs, notions, key words, oral presentation of products …
- photography is an efficient means of communication with parents; presenting learners' work to parents.

In addition, photography was not only the means of learning but also the objective. Teachers wrote that the pupils learned

- How to use the camera and computer (uploading and editing photos, presenting photos using PowerPoint);
- Principles of photography, purpose, selection of scene, selection of the right moment, light

As for the question of whether during the project the differences in ICT skills among the pupils decreased, the answers of teachers were different. The teachers who worked with smaller groups of pupils outside regular classes thought that the differences in the knowledge of pupils had increased, which is understandable. Three teachers thought that the differences remained the same. Only the teacher who uses photography most frequently and in very different activities believed

that the differences in the knowledge of pupils decrease with the use of such a method of learning. Therefore, periodical lessons with photography seem not to essentially improve the visual and ICT literacy of pupils.

4.6 Pupils' end-of-project evaluations of learning with photography

The questionnaire was filled in by 104 pupils from six classes – one third grade, one fourth grade and three fifth grades. There were 54 boys and 50 girls.

Table 1. Opinions of the pupils from the third to the fifth grade on learning with photography

Opinion	YES	NO	without
I like it when we take photographs at lessons.	97	6	1
All that I can do with the camera and the computer, I learnt at school.	4	100	0
Oral presentations of other pupils are more interesting when using photographs.	89	15	0
I like to work with photographs on the computer.	96	8	0
The photographs taken by other pupils are more interesting than those in the school book.	92	9	3
I prefer to watch photographs that to take them.	11	92	2
The photographs taken by the pupils are of bad quality.	11	86	7
I prefer drawing to taking photographs.	21	79	4
One has to learn how to take photographs.	35	59	10
I would like to learn how to make good computer presentations with photographs.	81	21	2
I prefer to learn new things on the computer and on the camera from other pupils and not from the teacher.	57	45	2
At lessons we looked at the photographs too many times.	9	94	1
I would prefer to make short movies than to take photographs.	67	37	0
I prefer watching photographs taken by the teacher than those taken by the pupils.	23	67	13
I would like photographs with me in them to be on the internet.	48	53	3

The pupils are enthusiastic about lessons with photography, i.e. about taking photographs and editing them on the computer. They prefer taking photographs to looking at them. Mostly (59) they believe they do not specially need to learn how to take photographs, they would like to learn how to make good computer presentations with photographs. Most of the pupils would prefer to learn working with the computer from other pupils than from the teacher. They find the photographs that the other pupils make more interesting than the photographs in the school books, or the photographs that the teacher takes. Even more than taking photos with the camera they would like to make films with the video camera. They did not think photographs were overexploited in the lessons. Only four pupils said that all they could do with a camera and computer they learned at school. Even though this number is small, it shows the digital gap among the pupils of lower grades which we believe is much higher in the overall population.

Conclusion

Learning with taking photos has its role and significance in primary education as in the world of communication with images qualifies the pupils not only as observers but also as reporters. The pupils included in the project were enthusiastic about learning with the camera and computer. The teachers were a little less enthusiastic about such learning, even though they recognised the educational significance of such lessons. At the conclusion of the project they felt that the pupils at the end of the sixth grade should know how to use a digital camera, save photographs, edit them and make PowerPoint presentations. However, the teachers also found that learning with photography disturbed the established lessons of social science too much, required too much organization and additional work, especially computer work, and so could not be used very often. Only one teacher with a lot of prior experience in using photography in class could do this during the project. Even though her pupils were used to photography, their opinions were similar to the ones of the pupils for whom this was a novelty and the change, and therefore a more attractive learning method.

Lacking ICT equipment in schools (one camera and a computer room is a standard) was an additional obstacle. For more frequent work with digital photos laptops are required that the teacher can bring to the classroom, a permanent camera in the classroom and the possibility of the use of five extra cameras, internet in the classroom and an LCD projector.

Learning with photography required the collaboration of pupils and also more equal collaboration between the pupils and the teacher as they learn together. In this project the traditional roles turned out to be an obstacle. The pupils prefer to learn from other pupils than from the teacher and the field of ICT is ideal for integrating peer learning into lessons and thus supporting a change from the transmission paradigm to a constructivist one. To enable this, curricula should be relieved of many details and the teachers should understand that the schoolbooks cannot be the principal organiser of lessons.
Considering the basic ICT knowledge of teachers it became evident that it is sufficient and they are able to carry out the work, but some of them would like to have additional courses, especially for the work with PowerPoint, which is used to connect photographs with other types of information in multimedia.

During the project we became aware that the teachers had the least knowledge of visual literacy. Only one participant of the project was concerned with this. Considering the three areas: ICT knowledge, didactic knowledge of teaching with the image and knowledge of the visual literacy, the latter is the most neglected. Visual literacy is included only in the curricula of the optional subject Education for the media and only on a declarative level among the objectives of the Art curriculum, without the inclusion of photography or film as the way of visual expression.

The least difficulties occurred in connecting photography with the content objectives of social science. The camera was most frequently used as an addition to usual activities, field trips or role plays, and it also played other roles such as evaluating the school. Of the range of elementary school social science topics, only history was not covered. We believe the reason for this is that history lessons rarely include activities which could be supported with photography.

Teachers in Slovenia found a place for learning through photography mostly outside of regular lessons or as a way to increase lesson variety. We shall conclude with the findings from similar researches abroad (Schiller and Tillett 2004; Bijnens and others 2006) which support our findings. The use of camera and ICT influences teaching and learning because the teacher needs to develop some skills along with the pupils and thus the constructivist approach is the only approach possible.

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GEOINFORMATION TECHNOLOGIES: NEW OPPORTUNITIES IN GEOGRAPHY EDUCATION?

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SUMMARY

Geography education reflects a new situation in the information society, the new expectations and needs. Geoinformation technologies (geographic information systems, remote sensing and global position systems) have become important in the practice of many branches of science and economics. However, many people are unable to use geo-information technology at the right moment for selection or acquisition of the needed information. Education in the use of geo-information technologies is still virtually neglected, especially at primary school level. The situation that can be defined, with a little exaggeration, as a clash between the 'digital' student and the 'analogue' teacher, is still frequent. At the same time, the number of schools equipped with computers increases as well as the number of new technologies which can be used for educational purposes. This paper presents some possibilities of using geoinformation technologies, especially geographic information systems (GIS) and remote sensing in geography education. The study also discusses the advantages and limitations of their usage. It also introduces some resources for teachers and students that can help them to become familiar with these technologies.

KEY WORDS: Geographic information systems, Geography education, Geoinformation technologies, Remote sensing

1 Introduction

Geoinformation technologies have become important in the practice of many branches of science and economics. The idea of Digital Planet

Earth (refer to the conference Digital Earth – DE, China, 1999) represents a new wave of technological innovation allowing us to collect, store, process and display unprecedented amounts of information about the Earth and its diversity of environments and cultures. However, the development of modern technology serves people only to a certain extent, especially when have not yet developed sufficient skill to use the technology at the right moment for selection or acquisition of the needed information**.** The Declaration on Digital Earth therefore states that while the global progress of the 20th century was characterised by rapid improvement of science and technology, which significantly contributed to economic growth and social welfare, the new century will be the era of information and spatial technologies supporting global knowledge economy. The European Union is well aware of the disproportion between the grand entry of geoinformation technology and the weak response to it in the educational systems, and is therefore making the use of geoinformation, especially practical skills in working with various portals providing spatial information, one of its principal educational objectives. The status of general level of skill of working with geoinformation in the Czech Republic corresponds to the state of the same in other EU countries.

2 Geography and Information and Communication Technologies (ICT)

For several decades, teaching elementary geography has been limited to tasks such as having students memorize the names of states and their capitals, recite definitions of landforms, or colour lines to represent locations (Stallworth, Braun, 2000). But, as Shin (2006) suggested, geography education should focus on learning about why things are where they are; instead students spend hours memorizing decontextualized sterile facts.

Information and communication technologies (ICT) are rapidly undergoing developments on a daily basis. They influence every aspect of human society, including the field of education. Teachers, textbooks and blackboards were the three most significant components of teaching a few decades ago *(*Demirci, 2009, p. 43). Now, blackboards are replaced

by the interactive whiteboards with data-projectors, and paper textbooks are being replaced by presentations, interactive software and educational programmes. Technologies also changed the role of the teacher from the traditional source of knowledge to a guide or a coach, and students have transitioned from passive to active learners. Conceptualiziations of the teaching process have changed as well. According to Scheffler (1999), learning comes from student inquiry, critical thinking and problem solving based on information accessed from a variety of sources.

ICT has provided teachers with a plethora of new tools; software, educational programmes, websites, communication technologies like email, videoconferencing and many others. These enable teachers to use innovative instructional methods, strategies and approaches. Teaching supported by computer can be defined as a learning process in which students work with computers, educational software or internet in order to search for information, do research or communicate, individually or in groups (Foltýnová, Mrázková, 2009). ICT should help teachers to get students to work independently and take responsibility for their learning.

Positive expectations of using technology in education have led many governments to initiate programs focused on the integration of technologies into schools. Within these programmes, schools were equipped with computers (Figure 1). Czech schools were beneficiaries of an extensive project called "Internet to Schools", which was designed to allow pupils to use this medium. However, supplying schools with a large number of computers does not necessarily mean that educational goals of integrating technology into the curriculum are accomplished (Demirci, 2009, p.44).

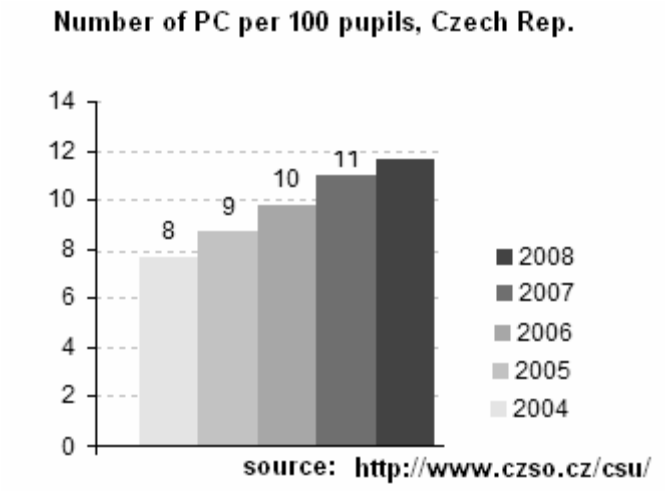


Figure 1. Number of PCs per 100 pupils in Czech schools.

Geoinformation technologies such as the geographic information systems (GIS), remote sensing (RS) or global position systems (GPS) are important ICT developments. They are especially useful for teaching geography, although they were not originally constructed for teaching or learning but for geography as a science. Geoinformation technologies are quite new tools in teaching geography; GIS, for example, has been used in education over the last two decades (Demirci, 2009, p. 44). Geography teaching can then be supported by cartography. From this point of view, geo-informatics may ideally be used as a synthetic subject forming a link between geological science and informatics. Geoinformation technologies can be used in geography teaching, but their incorporation into education is quite demanding.

3 Geographic Information Systems (GIS) as a new opportunity in geography education

A **geographic information system** (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. It allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports,

and charts (What is GIS?, 2010). GIS tools enable users to create different thematic maps based on data stored in databases. Data can be shown as points, lines or areas. The main advantage of a GIS is that it is dynamic – when data are updated, the map is updated, too.

The Geography Education Standards Project (1994) stated, 'the power of a GIS is that it allows us to ask questions of data.' Shin (2006) asserted that a GIS can be an effective teaching tool in classrooms because it can facilitate students asking and answering geographical questions. By using a GIS, students can get their hands on many different kinds of geographical and geological data and use them to answer complex questions about the earth and its resources.

As Kerski (2003) suggests, GIS is not the type of tool that a teacher can implement into education immediately, nor can it be easily included in the curriculum. This is the irony of GIS – if it were 'plug and play', more teachers would use it, but much of the functionality and flexibility would have to be removed. He also noted that the tool itself has no answer – these come from human operators.

Foltýnová (2008) made a half-year experiment which was focused on the role of GIS in geography teaching. As a GIS allows students to be active users of spatial information, learners were encouraged to acquire the skills to search, sort, and analyze information and discover the specific relations between them. *The main emphasis of the research was placed on the observance of principles and metacognitive training in order to achieve a desirable level of self-regulated skills.*

Many studies concerning GIS state that it is an effective tool to develop students' geographical or map skills such as analyzing or making inferences from spatial data and to enhance student and teacher motivation (Shin, 2006; Lemberg, Stoltman, 2001).

According to the Balderstone (2006), the arguments for using GIS can be summarized as follow:

- It is a 'real world' tool that can help bring career relevance to work in geography.

- It is the only ICT application that is specific to work in geography, though it does have uses in some other subjects such as biology or history.
- It offers enormous potential to raise levels of achievement in geography, e.g. by raising the quality of mapping and the ways in which maps can be used to support analysis in geography.
- It provides tools to process raw data, thus making more time available for analysing and making use of the data.

In spite of the potential benefits of using GIS in geography teaching, their integration into school curricula has been slow (Kerski, 2003; Incekara, 2010). The reasons for that can be: the cost of software, the lack of teacher training in the use of GIS software, and lack of access to ICT and vector based digital maps (Balderstone, 2006).

The main issue which can be seen among the Czech geography teachers is how to incorporate GIS into the geography curriculum. GIS and Remote sensing both lie on the border between geography and information technologies, and could be incorporated into both of these subjects. Looking at the Framework Educational Programme, GIS are set as part of geography. They should be used when teaching about cartography and maps (Framework Educational Programme, 2007) which is usually realized done in the sixth grade. However, in order to use GIS effectively to its full potential, students should have basic knowledge of regional geography. GIS enables students to analyze patterns in global economy or human issues (like poverty or literacy), so it is also good tool for teaching about global issues. Thus, GIS can be incorporated into curricula in all grades and also in subjects beyond geography. Although GIS has many advantages, Shin (2006) points out that it should not be seen as the only or even the best tool to teach geography.

4 Application of GIS to Geography teaching

A good way to start teaching and using GIS is to come and visit the GIS Day. GIS Day is a world-wide event which takes place any particular day in November, and any school can participate. A lot of Universities and other institutions open their doors to the public and invite people to

demonstrate their work and skills with GIS (Figure 2). Universities, Faculties of Education in particular, hold workshops either for teachers or for students to present the fundamentals of working with GIS. While there is no financial assistance for GIS Day events, there are many resources and tutorials for potential hosts which can be useful for teachers as well.



Figure 2. GIS day - students work with GIS, Arc Explorer software

GIS days also feature other software which can be very useful as teaching aids. Some of them are downloadable for free, others must be paid for. One of the largest software companies and the largest geoinformation software company in the world is ESRI (Economic and Social Research Institute). They have created unique software for educational purposes – Arc Explorer Java Edition for Education, which is downloadable for free. It enables students to deal with the fundamentals of working with GIS and to create basic maps. The same institution has produced an educational package including the most complex software called ArcGIS. Schools can also order a special educational package including the basic product level of ArcGIS – ArcView.

Teachers can use ESRI Virtual Campus, web pages that are focused on training teachers to use geographic information systems. Many of these online training courses are free, the only requirement is registration.

As mentioned before, there are still some reasons why teachers do not include GIS into geography teaching. One of them, which could be easily overcome, is access to data or digital maps. Nowadays, many databases are available on the internet. For instance, ESRI provides a number of worksheets on their website. These include not only tasks for students but also packages of data, manuals for teachers and methodology papers. Another data source is web map servers (WMS). Many companies, such as Geoportal Cenia, Czech Geological Survey in the Czech Republic, OGC Services or USGS (United States Geological Survey) offer free maps that can be easily used as data for GIS. Further sources include CDs attached to many publications about GIS, books such as *Mapping Our World* or GIS lessons for Educators by L. Malone et al, issued by ESRI Press. This book contains many samples of lessons using GIS, and focuses on geographic inquiry models used in American GIS - geography education.

5 Remote sensing and geography teaching

Development of information technologies allows us to use satellite and aerial images in geography teaching. Satellite image servers provide many materials based on remote sensing technologies: e.g. Google Earth (Figure 3) shows images of places around the whole world. Also NASA provides LANDSAT image mosaics from two horizons (circa 1990 and 2000). ESA issued the ESA atlas of satellite images with a teacher´s book which is free for schools. It seems that the golden era of using remote sensing in geography teaching has just begun.

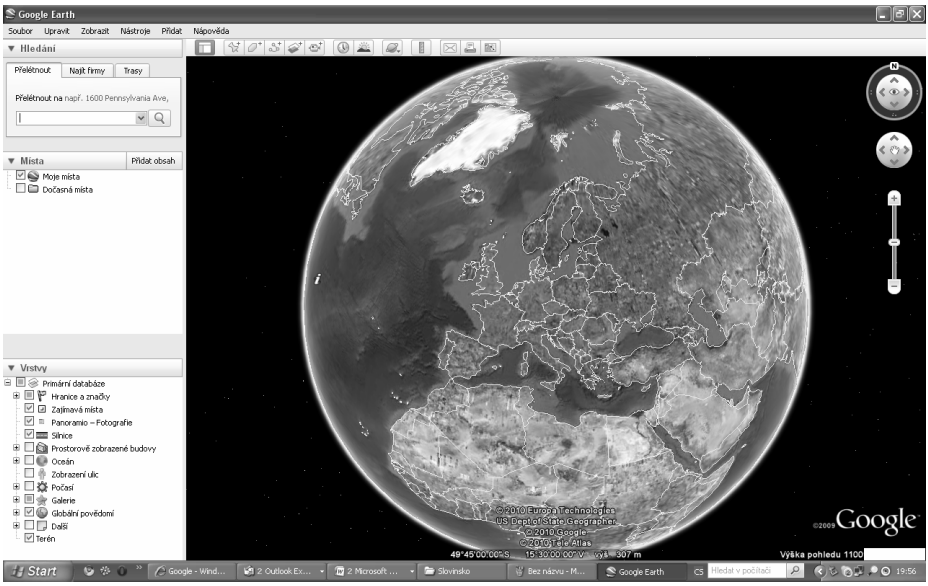


Figure 3. Application Google Earth – opening view.

Remote sensing analyses the Earth's surface and its changes with the help of aerial photographs and satellite images (*Figure 4*). There are many differences among aerial photographs, satellite images and maps of the same area. The use of photographs and images implies decoding and interpreting them. Svatoňová and Lauerman (2010) say that the main task in the interpretation of images is systematic reading, which consists of the following steps:

1. Identification and classification of individual objects.
2. Determination of their qualitative and quantitative characteristics.
3. Spatial location.
4. Research and evaluation of spatial relationships and aerial differentiation among the individual objects.
5. Analysis of spatial relationships and aerial differentiations; survey of main features of the pictured area.

The two main difficulties in the identification of individual objects in an aerial photograph or satellite image are perpendicular view and unnatural colours. First the reader should identify the main objects, such

as forests, fields, water areas, residences, and then differentiate between areas with or without vegetation.



Figure 4. Students of geography work with historical and modern aerial photographs to analyse land use changes over the last 50 years in the Moravian Karst

Our experience proved that the most important problem with images and photographs interpretation could be summarized as follow:

1. Perpendicular – it is not possible to perceive elevation.
2. The perception of elevation is conversed due to incidental shadows.
3. Unnatural colours – false colour: for example red for vegetation, purple for residences and light blue for glaciers.

Despite the problems mentioned above, we think that materials from remote sensing technologies should be included into teaching materials. The main advantage of using aerial photographs in geography teaching is that they enable students to look at the Earth's surface from a bird's-eye view. They can be used for historical surveys of landscape changes, or they can help students to see the landscape in a more complex way.

The same goes for satellite images. Teachers can use them to show students the impacts of natural hazardous earthquakes – for example students can analyse changes in the landscape after the disastrous tsunami in 2004, and say how the country is dealing with the destroyed seaside. You can also use them to demonstrate the fast spread of the biggest cities in the world, e.g. Dubai (see Figure 5).

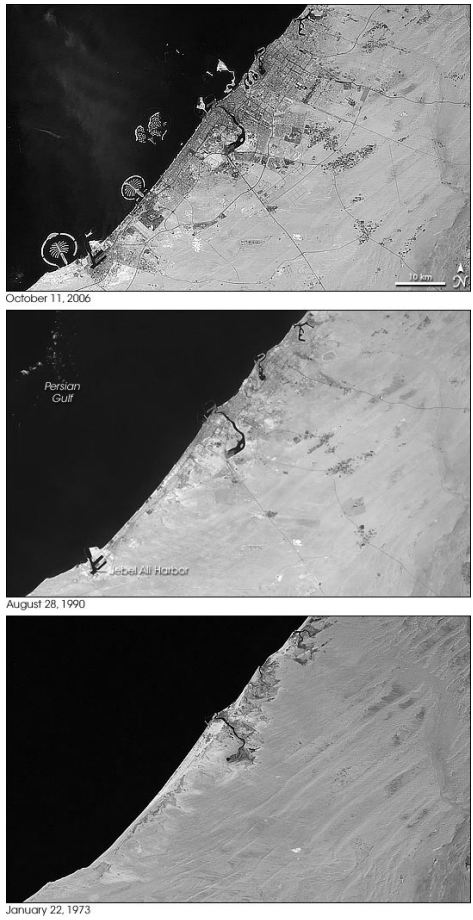


Figure 5. The Urbanization of Dubai , United Arab Emirates (retrieved from http://earthobservatory.nasa.gov/IOTD/view.php?id=7153)

The well known software Google Earth can be used to enable students to explore the Earth's surface by viewing satellite images, maps or terrain. Students can go through canyons, visit cities or see the night sky. It could be said that the ArcGIS Explorer, software developed by ESRI, is a

combination of Google Earth with geographic information systems. Students can present their layers and data prepared in any GIS software and show them on the Earth's surface. The main advantage of both sets of software is they are freely downloadable and do not require powerful hardware. However, internet access is a must as they retrieve data from internet databases.

6 Small research

The research on the use of geoinformation technologies in Moravian primary schools was carried out in the year of 2006 (Foltýnová, Svatoňová, 2007). It focused on the use of satellite images and interactive maps on the internet. 71 teachers participated in the small-scale study, of which 31 men and 40 women. The research tool was a questionnaire with open questions. The teachers' answers were categorized and evaluated. Results proved that computers and internet were used frequently in geography lessons, but more than half of the teachers did not use any geoinformation technologies, although they are aware of the freely downloadable software and free materials for geography teaching on the internet. They said that they would appreciate new software and methods for geography teaching, but they also pointed out many barriers: slow internet connections, lack of computers and lack of time during geography lessons, no training for teachers and sometimes also the age of particular teachers.

7 Geoinformation Technologies and Literacy

For centuries literacy, in the sense of reading and writing, used to be the benchmark for community education and a sign of the value of an individual for the community. What was once a privilege of a narrow group of people developed over centuries to become one of the basic human values. States invest money into active knowledge of reading and writing acquired in the course of the first years of elementary school education of their citizens. Literacy opens ways to further education. With the changing world, however, the society requirements change too; the original meaning of literacy has been considerably extended. The

latest extensions to the notion of literacy include the today fundamental computer literacy. As information literacy includes geo-information literacy, let me explain how some authors understand it.

Stansfield (2002) maintains that geoinformation literacy consists of geographic, cartographic and information literacy. The distinction between geographic and cartographic literacy follows from the distinction between the two branches of science themselves, even though the two overlap to a certain extent. Generally speaking, what is geographic (i.e. spatial), may be expressed cartographically, and vice versa, i.e. what can be expressed cartographically is spatial and can be subject to geographic research. Performing different tasks with geo-information methods today requires all aspects of geo-information literacy, even though to different extents. Voženílek (2002) says that geo-information literacy is not a sole privilege of individual experts in geo-informatics. As a consequence of compulsory school attendance, especially secondary and university education, a number of elements of geo-information literacy become part of everyday life of every expert (natural scientist, cartographer, computer expert, economist, manager etc.) Geo-information literacy is not only an ability to comprehend a special set of issues, procedures and activities using geo-information technologies, but also a tool of generation of new knowledge, approaches and decision-making materials.

8 Discussion

The number of new technologies which can be used for educational purposes is increasing rapidly today. However, incorporating these technologies into schools curricula and using them effectively in teaching is not easy. In the Czech Republic, the implementation of information and communication technologies is limited. In the main educational document – The Framework Education Programme (2007) – ICT is still featured mostly as part of a special subject called Information and communication technologies. According to the Framework Education Programme for Elementary Education, that subject enables students to develop basic ICT skills and acquire the basic level of information literacy. Mudrák (2005, p. 14) suggests a different approach to incorporating ICT into education, which is more familiar in West

European countries or in the USA and Canada, in which ICT is used as part of all teaching subjects and is thus completely incorporated into the school's curriculum.

The number of methods for using geoinformation technologies geography teaching is increasing. Electronic mapping and Interned-based mapping are a few of the many new techniques which can be used in teaching geography today (Demirci, 2008). Studies suggest two methods that are widely utilized: project-based learning and applied learning. In project-based learning, geography lessons are supported by projects in which students use GIS. The use of GIS in applied learning usually consists of students implementing a GIS-based application in a geography lesson (Demirci, 2008; Baker, White, 2003).

Some authors suggest that using geoinformation technologies in geography teaching improves the motivation of students. For example, Baker and White (2003) claim that the use of collaborative GIS has great potential for moving students quickly beyond practicing mapping where things occur into determining why things occur. This type of activity, which is one of the aims of many standards, appears to be improved through the use of geoinformation technologies. Also Kerski and Wanner (1999) suggest that the use of geoinformation technologies and methods has huge potential for issue-based and inquiry-based education. According to Lemberg and Stoltman (2001), these technologies raise the levels of motivation and interest in geography education, and Wiegand (2003) underlines the importance of these technologies because they help students to understand or read a map.

Education using geo-information technologies is not neglected in theory, but there is a lot of room for development in practice and there are no visible results of geoinformation education of the public yet. One of the reasons is probably the ever wider gap between the young generations of today, the 'digital student', and the adult generations, including the 'analogue' teacher.

9 Conclusion

In our experience, teachers of geography are inclined to learn about new technologies and approaches, especially when they see examples of good practice and are convinced that geoinformation technologies are not something a teacher could not master. We have also received teacher-originated proposals to Centres of Pedagogical Education for GIS lecture series. The GIS laboratory of the Department of Geography, Pedagogical Faculty, Masaryk University in Brno, is ready (technological equipment and human resources available) to provide lectures in geo-informatics to geography teachers or teachers of related subjects. A syllabus has been designed to provide sufficient theoretical knowledge of GIS and the relevant practical skills to the teachers fully covering the needs of elementary and secondary school education. The author of the article believes that introduction of geoinformation technologies is in full harmony with the Framework Education Programme (see above). It is up to the teachers of informatics and geography whether they make use of these technologies and materials and incorporate them into their teaching. The practice confirms the well-known fact that "everything is possible if you want to make it possible".

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THE IMPACT OF LEARNING IN THE INNOVATIVE COMPUTER ENVIRONMENT MUSICAL IMAGE FORMAT, RHYTHM ON MUSICAL ACHIEVEMENTS

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ABSTRACT

The paper presents *Musical Image Format, Rhythm*, conceived on the principles of an information–communication learning environment and on the paradigms of constructivist learning and teaching. Within The Republic of Slovenia this is the first attempt of a transfer of the music image format into a digital environment. The results of the experimental research, where the mentioned computer environment has been used, show positive implications for the development of rhythmic abilities and skills as well as for the use of the musical rhythm image format. Some positive connections between certain aspects of musical skills and the computer technology competences in case of blended learning (combination of e-learning and classical learning in the classroom) have also been manifested.

KEY WORDS: Didactics of music, Music education, Rhythmic skills, Musical image format, Computer environment, Musical Image Format, Rhythm, Computer literacy, Innovating pedagogical practice.

1 Introduction

For teachers who want to develop innovative approaches and methods of teaching and learning introducing changes and experimenting with novelties is a challenge. It is a challenge also for all those dealing with the conceptualisation and formation of new learning environments and didactic tools. These have recently often included the use of modern

technology. ICT has been changing both the strategies of teaching and the processes of learning (Roblyer 2003, Gardner 1983). When developing new didactic materials, it is therefore important to carefully plan the follow up and evaluation of their integration into the instruction. While doing that, we are primarily interested in the adequacy, applicability and effectiveness.

The developmental and open curriculum for music education offers opportunities for carefully considered introduction and consolidation of innovations in the area of didactic approaches to learning and teaching music with the support of modern technology. Based on the encouraging results achieved by experts at the MIT[11] and TIME[12], we created a computer learning environment called *Musical Image Format, Rhythm* [13] (Borota, Brodnik 2007), which was trialled in an evaluation study in 2007 (Borota). In that study we used the exploration research method to establish the ground for further experimental research work.

In the present paper we examine the impact of introducing the mentioned modern digital environment into the music instruction in the third grade. The innovative use of ICT is presented from the perspectives of external and internal integration of modern technology into music instruction. The main research questions were the purpose and the frequency of the use of the tool, and the impact of learning in the

[11] Meassachusetts Institute of Technology, where Jeanne Bamberger and Armando Hernandez (2000) developed the interactive computerised environment Impromptu. Learning in this environment is based on composing, researching and creating of musical motives or larger musical works. The music recording is based on the image format (fine arts symbols), which ensure successful learning also to those who have not mastered the conventional musical notation.

[12] Technology Institute for Music Educators is a non profit organisation providing help to teachers in the area of didactic qualification for the integration of modern technology into the musical education instruction. Together with ISTE (International Society for Technology in Education) they prepared national standards for the technology in education as well as standards for music in primary and secondary schools.

[13] Computerised environment is accessible at: http://iktglasba.pef.upr.si . For guest visitors a user name is provided – *demo* and password – *demo*. To participate in the virtual community, the users are asked to create their own usernames and passwords.

established computer environment on musical achievements regarding the experimental and control groups.

Teachers have to take into account also the level of pupils' computer literacy when planning pupils' learning in a computer environment. We therefore measured pupils' literacy in the computer environment to find at the end of the research the connection between computer literacy and music achievements.

We were highly interested in the above mentioned in order to better understand the learning processes and the creation of music with the help of music image format in the computer environment. Based on the results of this research we would like to continue with the development of the holistic didactic approach for learning and teaching music by using modern technology. Therefore the main focus of our research was directed towards finding the positive effects of learning in the computer environment *Musical Image Format, Rhythm* on pupils' achievement, principally in the area of rhythmic skills and knowledge as well as elementary orientation and the use of musical image format.

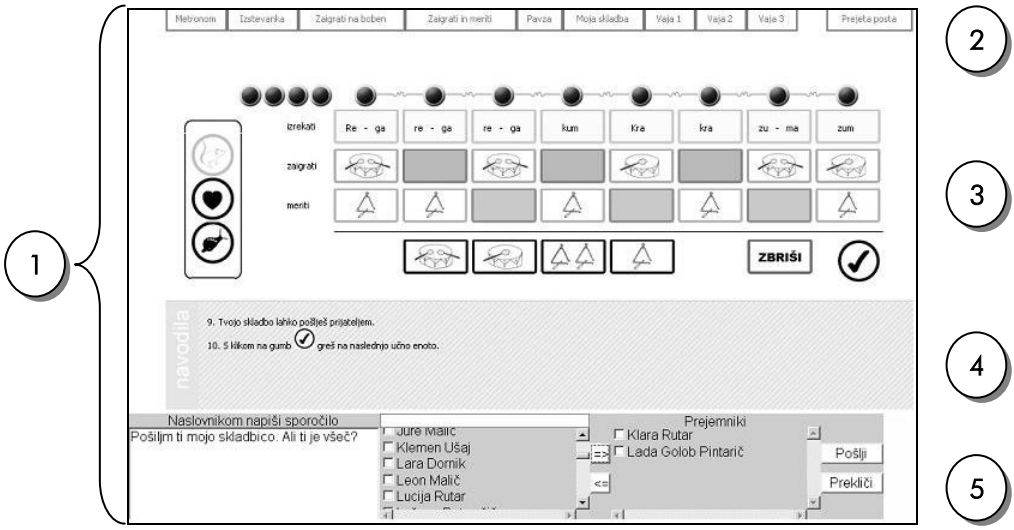
2 Presentation of the computer environment Musical Image Format, Rhythm

The technical implementation of the *Musical Image Format, Rhythm* is based on the idea of microword which makes it possible to link and deepen the experiences from real and virtual world (Papert 1993). This environment enables problem-solving learning in design space which helps us realise the modern paradigm of socio-constructivist learning and teaching (Kagan 1994, Glasersfeld 1995). The concept of the contents includes musical image format which represents an effective intermediate stage between the enactive and symbolic phase of concept development (Bruner 1968). The music image format or visualisation of musical contents is a suitable way of developing capabilities of elementary orientation in the music format, leading towards the use and the understanding of musical image recording.

For setting up the new computer learning environment for music we referred to the basic principles of how information-communication learning environments function and support constructivist paradigms of learning and teaching. Such learning environments have to provide the user with the following:

- focusing the attention on the selected problem/artistic challenge;
- using intuitive thinking for understanding new learning contents;
- simple learning and clarity of work;
- repeated cycle of learning underpinning the learning from experiences based on experiments and mistakes;
- creativity and individual construction of knowledge through open-ended tasks (Papert 1993).

The above principles are demonstrated outwardly in the user interface (Picture 1). The same format of this in all learning units enables an effective learning transfer both at the level of managing and the use of the computer and at the level of music knowledge transfer.



Picture 1. Main parts of user interface.

The constituent parts of the user interface are the same in all learning units.

1- **Programme window** is split into two permanent parts: activity/learning takes part in the upper part (3, 4), and the communication between pupils, between pupils and teachers or even with parents takes place in the lower part (5). Permanent arrangement of the parts in the window makes possible fast learning of managing skills and effective learning transfer.

2- **Learning units menu**. The user chooses learning units by clicking tabs. The menu conceived this way provides clarity of work and simple switching between learning units. The user knows at all times which unit s/he is in. A learning unit deals with one learning/creative problem/challenge. Units follow each other in a logical sequence of deepening and broadening music experiences and knowledge, from detecting music beat and finding relationships between measure and rhythm to music recording/format and opportunities for creating rhythmic motives and multi-sound instrumental composition. Learning in each unit can be repeated randomly any time, leading to the same or new solutions of music creation challenges, depending on unit objectives.

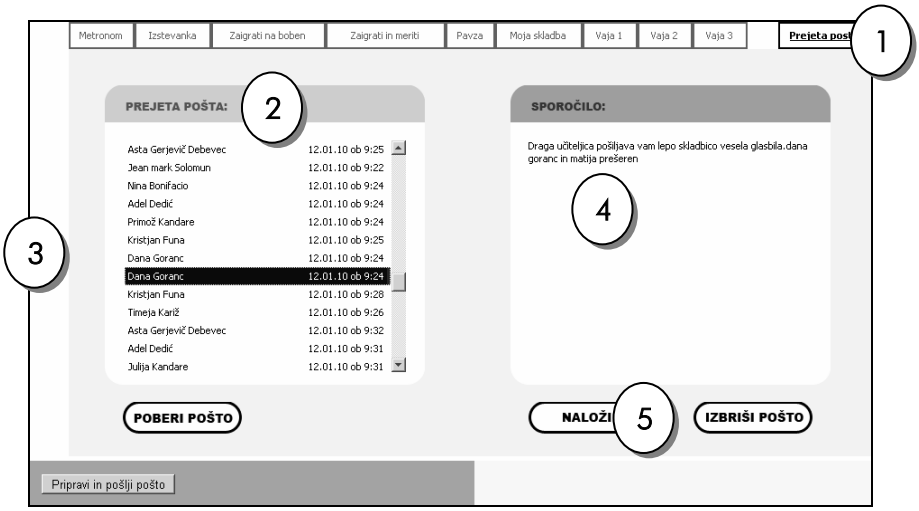
3- **Working space** is clearly distributed into two parts. Selection buttons are on the left, and the buttons for the central part with the learning contents and the buttons for musical image format are on the right.

4- **Learning instructions** are an important element of the learning environment, supporting independent and cooperative learning. The instructions area can be recognised by the grey background and the »Instructions« label. The presentation of instructions is not time limited and users can read them slowly and many times. The instructions are divided into several steps (short statements) and are displayed consecutively. When a user has completed the previous step successfully, the instructions for the next learning step are displayed. Thus the learning path which users follow is clearly defined. For better clarity, the buttons are equipped with pictures which make the written instructions more comprehensible.

Users get feedback on their learning success in the same gray space. Feedback mostly focuses on adequately written rhythm. The computer does not immediately offer the right solution; instead, it

directs users to make their own revisions. Only after the second false attempt are users addressed to ask for help from others, e.g., teachers or friends. After three false attempts the computer offers help by marking places with inadequately written music rhythm.

5- **Virtual environment** enables cooperation or partnership learning between users who are logged in the computer environment with a previously provided user name and password. Setting up a communication space in the same programme window reduces the working space; however, it enables effective use of electronic mail also to less skilled users. In case of sending text messages and multimedia materials, no prior saving of files is necessary nor is it necessary to use other computer tools for sending and receiving mail. A user's mailbox is located right of the menu line. By clicking the tab, a new user interface appears (Picture 2).

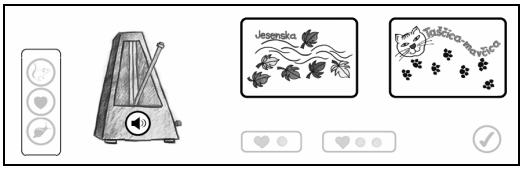
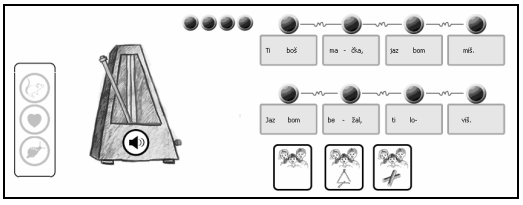


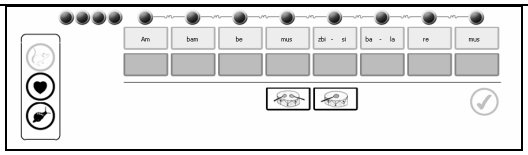
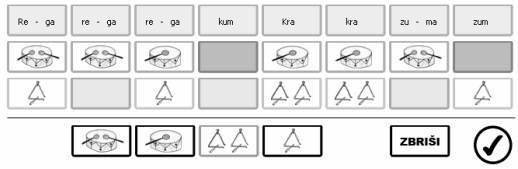
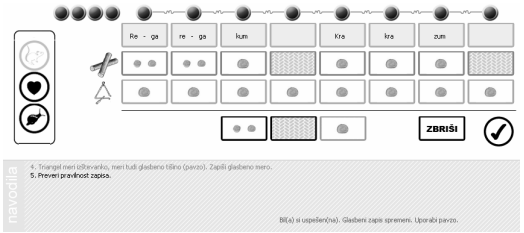
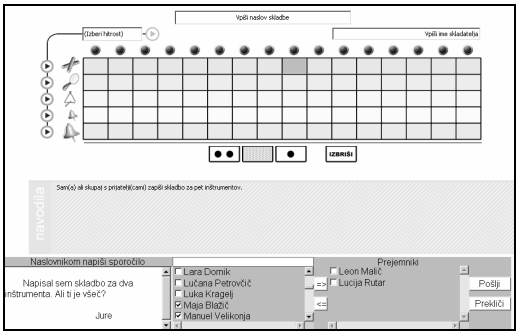
Picture 2. Graphic interface for incoming/received mail.

Clicking the tab *Incoming mail* (1) opens a graphic interface for incoming mail (Picture 2). The list of received mail appears automatically (2), with data on sender and the date and time of the mail. A click selects the sender by colouring them blue (3). In the text window, the text of the e-mail is displayed (4). In our case two pupils who worked together on writing a multi sound instrumental composition wrote: »Dear teacher, we are sending you the composition Merry instruments.« By clicking the

button »Download« (5), the window of the learning unit opens up in which the sender formed the multimedia materials, in our case a multi sound instrumental composition. By clicking the standard listening buttons we can listen to the composition. Using the same procedure as described above, the recipient can return mail to the sender or send them a new message and new multimedia material.

In the continuation we present the content and the learning processes in each individual unit. The topic embraces nine teaching units in the following sequence: Metronome, Rhythmic text, To play the drum, Rhythm and beat, Pause, My composition, Exercise 1, Exercise 2 and Exercise 3. A short presentation of the contents will contribute to better understanding both of the learning processes and the results of the experimental research.

Learning units in computer environment *Musical Image Format, Rhythm*	Process learning objectives in connection with the knowledge standards for the first triad of Primary Schools
Working space in the learning unit **Metronome**. 	Multimode perception as well as metrum follow up and performance. Observing the impact of tempo changes on musical performance. Getting accustomed to the use of computer and mastering learning strategies in the computer environment.
Working space in the learning unit **Rhythmic text**. 	Recognition of harmony between textual and musical rhythm. Understanding relationship between beat and textual rhythm. Training the skills of interactive buttons use.
Introduction of image rhythm format into the learning unit **To play the drum.**	Analytical perception of textual and musical rhythm. Deepening music perceptions; the harmony of between the period and

	one longer and two shorter sounds. Developing basic orientation in the image format. Training the skills of recording by using the interactive buttons.
An example of unfinished rhythm recording of Rhythmic text in the learning unit **Rhythm and beat**. 	Evenly performed beat and rhythm. Expressing rhythmical and rhythmised texts. Deepening orientation in the image rhythm format and measures. Creating rhythmical accompaniments to the selected Rhythmic text. Mastering the use of interactive buttons for the image format.
Teaching unit **Pause**. In the instructions area the recording of the feed back information on the successfully solved exercise is available. 	Deepening experiences with musical silence/pause. Maintaining steady regular musical beat together with measuring pauses. Independent learning – following instructions and feedback on the learning success.
Recording musical scores in the unit **My composition**.  In the bottom part of the window pupils have written a short text message which they will later send, together with a recorded composition, to their friends.	Creating a multi-sound instrumental composition. Developing music images on sonic periods, sound colour harmonies and perceptions of musical unity and its parts. Encouraging pupils to evaluate creative achievements. Participating in a virtual community.

The contents presented above are followed by three more units dedicated to consolidation and assessment. Teachers can partly adjust the exercises to the individual needs of pupils. Teachers send pupils the exercises with instructions through a virtual community. Pupils open the mail box (see Picture 2, sign 1), do the assignments and send their finished products back to teachers.

The wide accessibility of the described computer environment http://iktglasba.pef.upr.si opens up opportunities for learning at home. Parents can also be included in the learning processes and result interpretation. The precondition for that is internet access.

3 Relationship between learning in the ICT environment and the results of pupils of the 3rd grade of primary school

The introduction of the established computer environment was expected to bring changes and improvements in the school practice through the process of innovation (Valenčič Zuljan 1996). The research project had two phases. In preparation phase we selected participating teachers who had already been familiar with innovating teaching practice in the area of modern technology implementation, and then worked on establishing partnership connections and training teachers in the use of the new ICT tool. After connecting previous experiences with the new knowledge, we created an action plan for the research with a time framework. The objective of the research project as a whole was to:

- include the established computer environment as a didactic tool into the teaching and learning of music in the 3rd grade;
- verify experimentally the impact of learning in the established computer environment on the achievements of pupils in the area of rhythmic skills and knowledge as well as elementary orientation in the music image format.

The second phase of the research took place for seven months, from September 2009 to the end of March 2010. Both the experimental and control groups had one hour of music instruction twice a week, as per

the national primary school curriculum. In the experimental groups, however, instruction was planned as a form of blended learning[14].

3.1 Research questions and hypotheses

The general research hypothesis was:

Learning in the computer environment will have a positive impact on the pupils' achievements in the area of rhythmic skills and knowledge as well as in the area of the music rhythm image format.

Below we present the objectives, the research questions and the hypotheses derived from them.

1. Inclusion of established computer environment into music education
 1.1. What are the most frequent purposes of the introduction of the established computer environment into music instruction?

H1: *The established computer environment was most frequently included into music instruction with the purpose of clear perception of meter and rhythm as well as with the purpose of establishment of interaction.*

2. Learning in the established computer environment
 2.1. What is the impact of learning in the established computer environment on the perception of music beat?
 2.2. What is the impact of learning in the established computer environment on the steady/ regular music performance?
 2.3. What is the impact of learning in the established computer environment on the elementary orientation in the music rhythm image format?
 2.4. Does the level of pupils' computer literacy in the experimental group have any influence on their musical achievements?

H2: *Pupils in the experimental group will achieve better results in perceiving and performing musical beat.*
H3: *Pupils in the experimental group will have better results in steady/regular performance and in harmonising musical performance with the common tempo.*

[14] Combination of e-learning and learning in a traditional classroom.

H4: *Pupils in the experimental group will have better results in recording and performing after image format.*
H5: *There are no statistically significant connections between the results of music achievements and the level of computer literacy.*

3.2 Methodology

The method employed was an experiment with elements of action research. We used the one-factor experiment with classes as comparative groups. The action research was carried out in the phase of planning and integrating the computer environment into the instruction as well as while developing suitable approaches to the encouraging and surveying the musical and computer literacy of pupils.

4 Sample

Six classes of the third grade of four primary schools participated in the research. The experimental group was composed of three classes and three class teachers who carried out the music instruction by introducing the computer environment. The control group, too, consisted of three classes and three class teachers. The instruction here did not include using the computer environment.

Table 1. The numbers (f) and percentages (f%) of pupils by gender and by groups.

Participating pupils	Experimental group		Control group		Total	
	f	f (%)	f	f (%)	f	f (%)
Boys	36	55,4	36	50,7	72	52,9
Girls	29	44,6	35	49,3	64	47,1
Total	65	100,0	71	100,0	136	100,0

In total 136 pupils participated in the research. The groups were almost equal in terms of number and gender. The number of boys was equal in both groups and there were six girls more in the control group than in the experimental group.

Before starting the research we tested the equality of the experimental group and the control group in terms of their musical skills by using the t-test for independent samples.

Table 2. Results of t-test before the research, to compare the average mark of musical abilities and skills and the use of image format of the two groups.

Assessment categories	Groups	N	Mean	Std. Deviation	Levene'sTest for Equality of Variances		t-test for Equality of Means		
					F	Sig.	t	df	Sig. (2-tailed)
Music beat perception	Exp.	65	2.32	1.105	2.984	.086	1.260	133	.210
	Con.	70	2.10	.950					
Performance in common tempo	Exp.	65	2.38	1.128	19.221	.000	1.388*	106.883	.168
	Con.	70	2.16	.715					
Music beat performance	Exp.	65	1.94	1.310	20.155	.000	.647*	108.970	.519
	Con.	70	1.81	.856					
Rhythmic expression of texts	Exp.	65	2.40	.981	5.864	.017	.093*	122.592	.926
	Con.	70	2.39	.786					
Performance of rhythm	Exp.	65	2.26	1.122	6.523	.012	.687*	119.513	.493
	Con.	70	2.14	.856					
Performance of rhythmic accompaniments	Exp.	65	1.92	1.065	1.894	.171	-1.012	133	.313
	Con.	70	2.10	.965					
Rhythmic motives image format	Exp.	65	1.75	1.090	1.899	.170	1.718	133	.088
	Con.	70	1.41	1.198					
Image format of tone periods and pauses	Exp.	65	1.46	1.133	.121	.728	1.439	133	.153
	Con.	70	1.19	1.094					
Performing rhythm after image format	Exp.	65	2.06	1.074	1.735	.190	.365	133	.716
	Con.	70	2.00	.885					

* Equal variances not assumed.

Before the research the experimental group and the control group of pupils did not show significant statistical differences in the categories of metrum perception, performance of rhythmic accompaniments, rhythmic motive image format, image format of tone period and pauses as well as in the category of the performance of rhythm by image format.

4.1 Data collection and data processing

Data was collected with the help of a 5-level assessment scale of musical abilities, skills and knowledge and semi-structured interviews with pupils and teachers who implemented the ICT tool in their music instruction. In order to find out the purpose and the frequency of the inclusion of the computer environment into the instruction, we analysed the lesson plans, teachers' reflection notes and documentary materials which resulted from instruction monitoring.
The data for the attributive variables are presented in Table 3. To test the differences between the group arithmetic means we used the t-test for independent samples. The correlation between the level of computer literacy and musical achievements was ascertained using Pearson's correlation coefficient.

Results and interpretation
The results of the research are presented in the same sequence as the objectives of the research and the research hypotheses.

Inclusion of the computer environment into music instruction
Models of introducing computers into instruction differ from each other according to teaching theories on which the school curricula are based (Roblyer 2003). Experts distinguish knowledge and internal integration processes. By external integration we introduce computers into specific levels of the education process and with the internal integration we encourage and support learning processes (Papert 1993). Experts have found out that the efficiency depends on careful planning in terms of contents and time in connection with the purposes and objectives of learning in the computer environment. We therefore wanted to know for what purposes the computer learning environment was integrated into music instruction.

We analysed fourteen lesson plans and collected data by interviewing teachers and observing instruction. We determined categories according to the aspects of media (computer) integration into the educational process (Blažič et al. 1993).

Table 3. The number (f) and percentage (f%) of purposes of the inclusion of the computer environment into instruction.

Inclusion Purpose	f	f%
Interactivity	17	45,9
Clarity	13	35,1
Information source	7	19,0
Total	37	100,0

In almost half of the cases (45,9 %), the computer environment was introduced into the musical education instruction with the purpose of enabling interactivity. The latter was manifested in the activities connected with the use of image format, in selection of learning contents and in the participation in the virtual community. Through this, interaction among pupils was established (cooperative learning, pair work - sharing the same computer, evaluation of results) as well as interaction between pupils and the computer learning environment (creation of image formats, selection of activities and the contents, sending and receiving e-mail).

The second most frequent purpose of the computer use was clarity. At the concrete and conceptual level clarity manifested itself the most in the multi-sensual perception of basic rhythm parameters (tempo, measure, relation between basic beat and divider beat) as well as in the concept building (tempo, longer and shorter sounds, colour and rhythmic harmony of multi-sound recording). On the basis of observations and reflections we found out that the clarity of learning content had a positive influence on the motivation and cognition processes as well as on the rationalisation of musical image format explanations.

From the collected results we can confirm hypothesis H1: the computer environment was most frequently introduced into music instruction with the purpose of supporting learners' perception of metrum and rhythm as well as with the purpose of establishing interactivity.

4.2 Learning music in the computer environment

The main purpose of the research was to verify experimentally the connection between blended learning (combination of e-learning and

learning in a traditional classroom) and pupils' achievements in musical rhythm and elementary orientation in the image format.

Sloboda (1987) ascertains that certain movement or performance is rhythmical if pupils are able to perform one of the following skills: division of period, measuring pause time, imitating rhythmic motive and/or harmonious movement /performance with music. The enumerated knowledge and skills, which determine performance as rhythmical, were planned, evaluated and assessed in our research.

4.3 Perceiving and performing musical beat15

Special attention was paid to the perception and performance of beat which makes it possible to hear and feel all other dimensions of musical rhythm. The ability of perceiving beat and maintaining a stable tempo of performance contribute essentially to a quality music performance. Contrary to other (fixed) time units, the beat has to be established again and again depending on the performance at a certain moment. Therefore flexibility is needed for the formation of time unit in each performance or in the repeated music performance (Bamberg 2000).

In the computer environment, the music beat perception stimulates multi modality: by stable, repeated pulsation of colour signals, by image format and its performance in sounds. Special attention is paid to these objectives in the teaching units such as: Metronom, Rhythmic text and Rhythm and beat.

The table below shows the results of the t-test for the comparison of the experimental and control group at the end of the research.

[15] Slovenian music literature uses several different terms to denominate the basic musical pulse. When listening to music it is felt and expressed as stable regular movement (nodding, swinging left and right, tapping a foot …). In this paper we use the term » beat« to measure regular musical time. Frequent other terms in the literature are »musical beat« and »period «. In English the term is usually interpreted as »beat«, the term »pulse« is rare.

Table 4. Results of the t-test for the comparison of achievements in the area of beat perception and beat performance after the research between the two groups.

Assessment Categories	Groups	N	Mean	Std. Deviation	Levene'sTest for Equality of Variances		t-test for Equality of Means		
					F	Sig.	t	df	Sig.(2-tailed)
Music beat perception	Exp.	65	3.34	.713	.143	.706	6.933	134	.000
	Con.	71	2.46	.753					
Music beat performance	Exp.	65	3.31	.705	.302	.584	8.389	134	.000
	Con.	71	2.21	.809					

The results indicate that the experimental group achieved statistically significant higher results both in perception (t=6,933, df=134, p=0,000) and performance of the beat (t=8,389, df=134, p=0,000). Pupils who were training their perception with the help of computers were better in the perception of metrum in the music of different pace and also better performed it through their motion.

The average estimation of the beat in the experimental group (M=3,34) shows that pupils can feel it by themselves in distinctive musical examples and successfully express it through their motion. The pupils of the control group who achieved lower average values (M=2,46) were in most cases successful with the help of others. Pupils in the experimental group accurately perform beat at a moderate tempo (M=3,31), while pupils in the control group reach their accuracy with the help of others, e.g., teachers.

The results confirm the second hypothesis, H2: pupils in the experimental group achieved better results in perceiving and performing musical beat.

4.4 Rhythmical performance and harmonising performance with common tempo

Music is often performed in teams in different singing and instrumental groups. Here the competence of an individual is to adjust and harmonise his/her performance since the tempo is set again and again in reference to performance at a certain time.

The ability of adjusting to a stable and regular tempo contributes to a consistent and accurate performance. Experts have found that pupils are more successful if they practice rhythm through a motor performance which has been well trained, as for example speaking (Rainbow, Owens 1979; in: Motte-Haber 1990). Rhythmic expression of texts is therefore a suitable way of reproducing various rhythmic motives with the intention of developing the feeling of stable, regular tempo.

Performing rhythm really means mastering the relation between the basic beat and divison, and for the latter it is important to feel the music beat and measure as the basic metrical unit (Gordon 1997, Sloboda 2007). Metrical units are shaped internally, in our imagination, even if we cannot recognise them from the musical format (Motte Haber 1990). Perceiving metrical order is very important since metrical hierarchies derive from it, and they can be recognised in children through the performance of three levels of metrum. We comprehend those relationships intuitively in an encouraging musical environment; and we also express them in that way when for example we express ourselves rhythmically, sing or play. We have to carefully plan the capability of redirecting the attention from one to other levels of metrum (Bamberger 2000).

When creating the computer environment, we were particularly careful about the graphic interface and video-audio prompts which would direct the attention to the perception of musical primary matters in connection with image symbols. Namely, attention has a special importance in the construction of perception. What appears in its focus is heard extremely well, and perception aims at the construction of symbols (Motte-Haber 1990). We can remember very well what we hear and see at the same time. Memory is an important element helping us to construct the performance vocabulary, and the latter is a precondition for creating and performing music.

The described area of musical development was covered in one of the research objectives, from which the third hypothesis was drawn and which will be confirmed on the basis of the results given in the table below.

Table 5. Results of the t-test for the comparison of estimations in the rhythmic performance after the research

Assessment Categories	Groups	N	Mean	Std. Deviation	Levene'sTest for Equality of Variances		t-test for Equality of Means		
					F	Sig.	t	df	Sig.(2-tailed)
Performance in common tempo	Exp.	65	3.34	.691	.784	.377	7.852	134	.000
	Con.	71	2.45	.628					
Rhythmic expression of texts	Exp.	65	3.49	.664	.381	.538	8.424	134	.000
	Con.	71	2.49	.715					
Rhythm performance	Exp.	65	3.25	.771	.036	.851	6.729	134	.000
	Con.	71	2.35	.776					

The t-test results confirm that the two sample groups differ significantly in average estimations in group/team musical performance (t=7,852, df=134, p=0,000), in rhythmical expression of texts (t=8,424, df=134, p=0,000) and in performing rhythm (t=6,729, df=134, p=0,000). In all the categories the pupils in the experimental group achieved better average values. Their achievements were manifested in harmonious musical performance, in accurate expression of rhymed texts and count-outs as well as in steady regular performance of song rhythm.

The calculation of the correlation between the estimation of beat and the adjustment to the common tempo showed a high and positive (r=0,905) as well as statistically significant connection at the risk level of p=0,01. A high and positive correlation was discovered also between the assessment of rhythm performance and adjustment to the common tempo (r=0,750) at the risk level of p=0,01. Hence, we can agree with the experts who claim that the ability of performing beat and adjusting musical performance to the common tempo influence the quality of rhythmic performance.

The results confirm hypothesis H3: the pupils in the experimental group reached better results in steady regular performance and in adjusting musical performance with the common tempo.

4.5 Musical image format

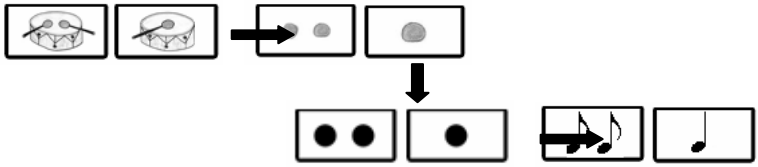
Learning music and developing musical literacy occur through the phases of listening, performing, reading and writing (Gordon 1997). The last two are not of key importance from the perspective of musical culture; however, they are welcome/necessary in societies where literacy is an important factor of democratisation and quality of life. Mastering reading and writing (music) enables us to become aware of certain things sooner and we understand them better. By using a symbol system we construct memory, organise our future activities and at the same time communicate with endless numbers of individuals (Gardner 1983).

Reading and writing music is a component of developing music literacy in primary schools. The music image format and graphic representation of music functions are the intermediate stage before the use of musical notation. The graphic representation of music is being researched by the American psychologist Jeanne Bamberger. She carried out three studies with children aged from 4 to 12. Based on her research results, she divided development in this area into two phases. For the first figural phase of musical rhythm, graphic representation is typical and children range symbols (dots, circles, curves) one next to another. This notation offers a certain general outline (frame) for example of a rhythmic motive, but we still cannot recognise the differentiation of the rhythmic perception. In the second phase, the phase of metric representation, children use symbols to adequately express the number and the length of beats (Bamberger 2000). Goodnow came to similar findings, i.e., that children in their early period do not express their perception of beat and division yet, but simply range dots /smaller elements one next to another. The phase of greater differentiation appears after the fifth year and develops intensively in the school period (Goodnow 1971 in: Hargreaves 2001).

In Slovenia music image format was introduced by Breda Oblak. She developed it in terms of visualisation of music and textual contents. Thus she illustrates the textual contents of the song with pictures; through their arrangement she indicates the melody movement, and with the size of individual figures the rhythmic structure (Rotar Pance 2002). Such an approach enhances children's creativity, development of

musical imagination and musical thinking. The visualisation of rhythmised texts leads children towards stable regular expression, clear diction and articulation. With its help, children develop their feeling of metrum and rhythm (same ref.: 29).

The above mentioned approach to musical rhythm image format was implemented in the creation of the computer environment. The image format was used at the level of the metric phase of the graphic representation of musical rhythm, which enables differentiation of rhythmic perception at the level of relation between beat and division. The imagery develops through teaching units from the concrete to symbolic level, which ensures fast transfer to the conventional musical notation (Picture 3).



Picture 3. The buttons images in the computer environment for rhythm recording.

The selection of adequate symbols is important as it helps to establish a connection between the musical abstractness and musical imagery. For pupils symbols are musical materials they use to compose sonic patterns. It is a type of exploration which is an important way for children to learn and get clear results in their musical achievement (Bamberger 2000). For children it is also much easier to recall a musical event through symbols (Borota 2006).

In our research we tried to find the connections between rhythmic skills and the use of music image format. The results have shown that the experimental group achieved higher results both in the category of music motives image format (t=10,364, df=134, p=0,000), sound periods and pauses (t=12,488, df=134, p=0,000) and in the category of rhythm performance after the image format (t=12,287, df=134, p=0,000). The differences in average estimations are big and statistically significant. In the case of recording rhythmic motives, the average estimation of the experimental group (M= 3,18) indicates that pupils are successful in

noting shorter rhythmic motives, whereas pupils of the control group (M=1,86) heard rhythmic motives but still record more at the level of figural representation. In the category of rhythm performance after the image format the average estimation of the experimental group (M=3,49) shows that pupils, with the help of teachers, perform rhythm after the image format, whereas pupils of the control group (M=2,07), with the help of their teachers, read the image format with neutral syllables.

The described findings confirm hypothesis H4: the pupils of the experimental group achieved better results in noting and in performing after the image format.

4.6 The link between computer competences and achievements in music

Experts have found that we have at our disposal several independent abilities which function on the outside as a harmonious whole (Gardner 1983). Teachers have to, when planning integration, respect different levels of pupils' development in individual areas. Thus, it is necessary to know, for the purpose of successful planning of use of a computer environment, the level of pupils' computer literacy and their competences in managing computers (Roblyer 2003). For teachers it is also of considerable interest how strongly these competences are related to learning outcomes.

In order to determine the computer literacy levels of the pupils in our sample, we surveyed them in the following areas: computer management, mouse skills, knowing basic functions of the keyboard, the use of keyboard for writing texts and desktop orientation. For the calculation of the correlation we merged the categories into a new variable, and created two additional variables for the categories which are linked to the areas of music skills and knowledge as well as in the area of image format.

Table 6. Correlation, average estimation and standard deviation between the marks in computer competences, rhythmic skills and the use of image format in reference to the pupils of the experimental group at the end of the research.

	1	2	3
1. Computer competence	1.00		
2. Rhythmic skills	.446 (**)	1.00	
3. Image format	.513 (**)	.729(**)	1.00
Mean	15.85	19.54	9.83
Standard Deviations	3.068	3.86	1.91

** Correlation is significant at the 0.01 level (2-tailed)

The results show a high positive correlation (r=0,729) between the marks of rhythmic skills and the successful use of music image format. A moderate positive correlation also appeared (r=0,513) between the marks of computer competences and the use of music image format. We can conclude that a successful performance of rhythm after image format is influenced by developed rhythmic abilities and skills, and the creation of the rhythm image format in the computer environment is influenced also by computer competences. The results have confirmed the findings of experts about the connections between individual aspects of music abilities (Sloboda 2007, Hargreaves 2001).

Based on the obtained results we have to reject the hypothesis saying that there is no correlation between the results in musical achievements and the level of computer literacy.

Overall, the results of our study have shown that learning in computer environment *Musical Image Format, Rhythm* has a positive impact on the achievements in rhythmic skills and knowledge as well as in the area of the use of musical rhythm image format. The computer environment has proved to be an adequate didactic tool which increases clarity and interactivity in learning and teaching. An added value lies in the multi-code character of the materials since pupils have a possibility of

immediate establishment of connections between the image and sonic image of the format.

5 Conclusion

Musical Image Format is an effective didactic tool which provides an interactive learning environment and a high level of clarity in learning the basic parameters of rhythm. A suitably conceived user interface ensures clarity and the learning transfer of musical experiences and knowledge.
In our experimental research the computer environment was introduced in a context of blended learning, i.e., in a combination of e-learning and learning in a traditional classroom, and in terms of ensuring independent and cooperative learning. The results of the research have shown a positive influence of such learning in terms of achievements in the area of rhythmic skills and the use of musical rhythm image format.

In comparison with the pupils of the control groups, the experimental group pupils were more successful in recognition and performance of music beat, on the basis of which they effectively established other dimensions of musical rhythm. Encouraging achievements have been manifested in more accurate musical performance of rhythmic accompaniments and the rhyming of texts. In case of team/group performance they were able to adjust their performance much faster and more successfully to the common tempo. We assume that the multi-mode perception of music beat in the computer environment had a positive influence on the development of perception capabilities and on the performance of metrum in music.

Creation and noting musical motives as wholes with the help of fine art symbols is an important aspect of music learning. Symbols are a certain kind of musical material through which pupils create sonic samples. We have found that this is an area of music learning in which modern technology is very effective as it ensures that we can hear the sample which we composed at the visual level also in the sonic image. The results of the experimental group confirm positive correlations between the experiences gained this way and success in reading and writing of musical rhythm with the help of image format.

For teachers the finding on the connections of different aspects of musical abilities and skills with the skills of computer literacy is also very important. When planning learning in the computer environment teachers have to take into account the experiences and capabilities of pupils both in the area of music and in the area of computer literacy.

The positive results of our research suggest further opportunities for the development of computer environments for learning music and for the development of new approaches towards learning and teaching music with the support of contemporary technology.

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GEOMETRICAL PROBLEMS AND THE USE OF GEOBOARD

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ABSTRACT

The article presents problem-oriented instruction of geometry with the use of the geoboard. Geometry is considered to be very abstract, and it is therefore difficult to be taught. Teachers usually deliver their instruction in a very formal way and a number of pupils have difficulties in geometry. For that reason we decided to conduct a research in which we conceived a model of geometry instruction with the use of geoboard, in which the main activity was setting and solving geometry problems. We verified the suitability of our model with an experiment conducted with a sample of 113 pupils of the seventh grade of primary schools in the Littoral region of Slovenia. It would be very useful if the results of our research could be used for the modernisation of the mathematics curriculum for the nine year primary schools as well as for the education and training of teachers and students of mathematics and the authors of new mathematics textbooks and other materials for teachers and pupils.

KEY WORDS: Problem-oriented instruction, Types of geometrical problems, Taxonomic levels geometry, Geoboard

1 Introduction

The instruction of geometry in primary schools is based on observing and developing spatial imagery. The point of departure in mastering geometrical concepts is always primarily observation and practical work with concrete objects and materials. One of the most important didactic tools for this is the ***geoboard***, which is most often used to study basic geometrical concepts such as parameter, area, triangle, polygon, congruency, axis and midpoint symmetry, parallelism, perpendicularity … It provides pupils with visual imagery, which is the initial stage in learning geometry, and it can also be used for solving geometrical problems and discovering and studying new facts. A wooden or plastic plate of n×n dimensions with pins to which we attach rubber bands was invented by Caleb Gattegno as early as in 1950, but in Slovenia it entered mathematics instruction only in the last decade.

Geometry is considered to be very abstract, and it is therefore difficult to be taught. Teachers usually deliver their instruction in a very formal way and a number of pupils have difficulties in geometry (Allen, 2006). The Dutch mathematician Van Hiele (1986) has proposed that pupils should use geometry mosaics, compounds (tangrams), drawn plates etc., for learning. Manipulating and playing with the mentioned materials makes it possible for pupils to gather the necessary experiences for the construction of geometrical concepts. Beyond any doubt we should add to the above mentioned materials also the geoboard which helps to understand new concepts and makes the instruction of geometry more problem-oriented.
In our research we therefore implemented a problem-oriented approach to geometry instruction with the use of a geo-panel. Because the research focused on solving geometry problems, we shall first define this concept.

2 Geometry problems

According to Jauškovec (1993), Moates and Schumacher (1982) each problem is composed of three elements: unwanted initial stage, desired final stage and the obstacle preventing the transfer from the initial stage to the desired final stage.

Most of the mathematics–didactic literature, when defining the mathematical problem, also cites the geometrical problem with the same three components (Frobisher, 1996, str. 239-241), which are denominated a bit differently:

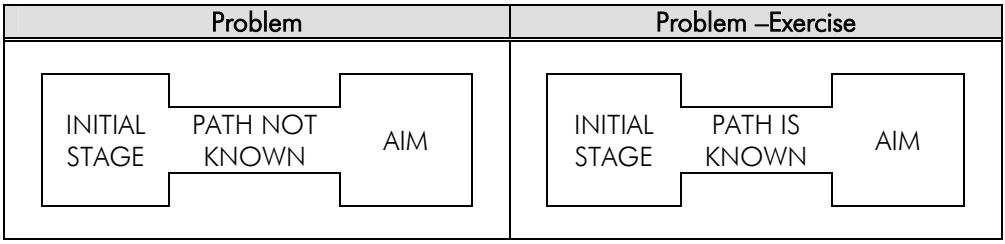
1. the initial stage or situation where the content of the problem with adequate data and information is given,
2. a goal to be reached by someone solving the problem,
3. the pathway from the initial stage or situation to the final aim which has to be found by someone in order to solve the problem.

This can be displayed in a diagram in the following way (Frobisher, 1996, str. 239-241):



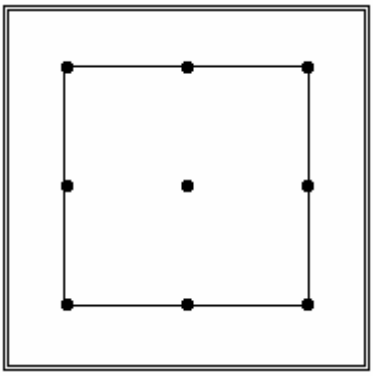
When the pathway from the initial stage to the final aim is known, and it is therefore not necessary to search for it, then we no longer speak about a mathematical problem. Hence, if someone solving a problem is acquainted with the strategy of solving it, we cannot speak of a problem anymore but about a *problem – exercise* or *routine problem*. In other words, a problem is a situation in which the person seeking a solution does not have at their disposal either a procedure or the algorithm which would safely bring them to the solution. The very same situation could be a problem-exercise for another person who already knows the pathway to the solution.

The difference between a problem and a problem – exercise can be presented in a diagram like this:



Let us have a look at all three components in the following simple example:

Example 1: *Form a square with the largest side on a 3×3 geoboard. What is the area of the resulting square if the area unit equals the area of the square with the shortest side?*



INITIAL STAGE:	PATH:	AIM:
Form a square with the largest side on a geo-panel 3×3. What is the area of the resulting square if the area unit equals the area of the square with the shortest side?	$a = 2\,e$ $p = 2 \cdot 2 = 4$	The area of the square is $4\,e^2$.

For the pupils who have mastered the formula for the area of a square, the path towards the aim is known and does not represent a problem – for them it is a problem-exercise. We marked 'e' the unit of length which is the shortest distance between the pins, and *E* stands for the area unit, i.e., the area of the smallest square that we can shape on the geoboard. For younger pupils to whom the concept of square dimension of a figure has only been introduced and who are not yet acquainted with the formula for the square dimension, the question is a problem, as they cannot solve it only from their memory, but through other mental procedures.

The difference between the problem and the problem-exercise helps to better understand what has been going on in the traditional teaching and learning of geometry. In regular school practice the teacher demonstrated to pupils the procedure and strategy for solving a certain type of problem, and pupils then practiced the procedure on similar examples. In those cases pupils merely applied the memorised procedures and strategies of solving geometrical problems in standard situations. However, as soon as the context of a problem changed, pupils were often no longer able to solve it. Besides, pupils most often met the type of problems with only one solution which was quickly reachable. The consequence was that pupils began thinking that every problem can be solved without much mental effort, and if the path to the aim is not evident, the solution to a problem must be impossible (Frobisher, 1996).

3 Types of geometrical problems

There are several types of geometrical problems which can be distinguished according to pathway and aim. Based on that definition, mathematical-didactic literature mentions three categories of problems:

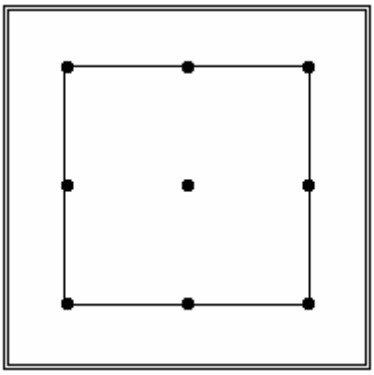
- problems with closed path and closed aim,
- problems with open path and closed aim and
- problems with open path and open aim (Frobisher, 1997).

3.1 Problems with closed path and closed aim



As an example we have taken the geometrical problem on the geoboard.

Example 2: *Form a rectangle with the biggest square area on the geoboard 3×3. What do we call the resulting rectangle?*



In the above example pupils quickly discover that squares are also rectangles. Many teachers and mathematics didacticians (Frobisher, 1996) believe that pupils should first be faced with problems such as presented above, since while solving them we can see whether pupils understand basic mathematical concepts and notions and at the same time consolidate them. Only after that we introduce pupils to the second category of problems.

3.2 Problems with open path and closed aim



Let us transform the above geometrical problem with the closed path and closed aim into a problem with open path and closed aim.

Example 3: *Form all possible rectangles on the geoboard 3×3. How many pairs of non-congruent rectangles can we get?*

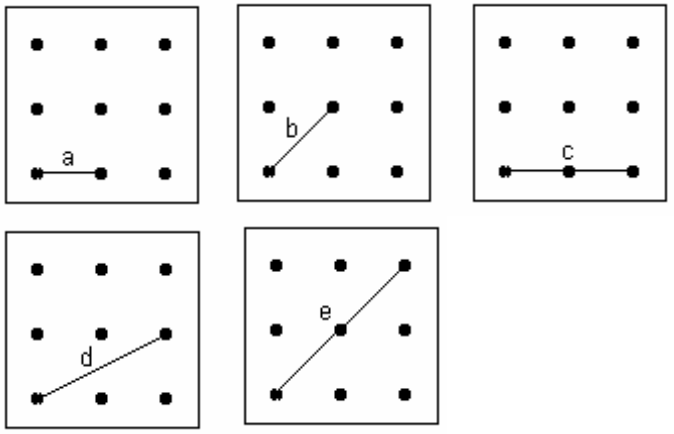
The aim is closed since pupils are expected to form as many rectangles as there are or as they think there are. The path is open because pupils have to look for their own solving strategy. Some pupils do not select

any strategy and look for different rectangles solely by the principle of chance while others take a systematic approach to the formulation of the solution. When pupils are solving this type of problems, they often use their previously trained strategies, but as soon as they are expected to change the strategy in order to be successful, they are not capable of doing it and simply resort to "blind" and random looking for solutions (Frobisher, 1997, str. 7). Pupils therefore need a lot of experiences and advice in order to become able to select and apply an appropriate strategy for this kind of problems.

Here are some different ways of solving problem No. 3 which were actually used by pupils:

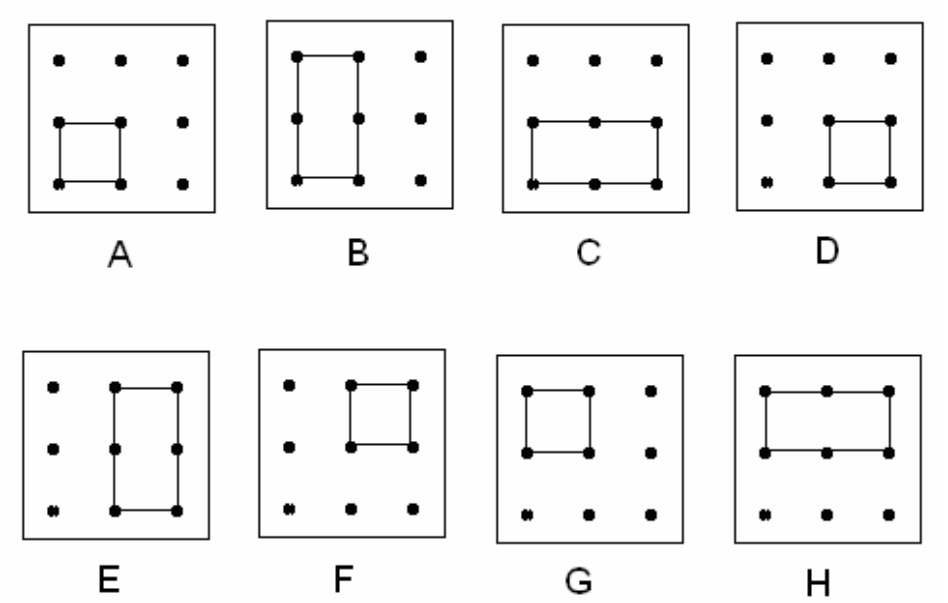
1st way: Pupils search for different rectangles non-systematically, i.e., not using any strategy. Soon they discover that this way they would not be able to find all rectangles or that here and there a rectangle reappears.

2nd way: They decide to look for the rectangles for example by the length of the shortest side. On the geoboard 3×3 there are 5 different lengths between the pins.

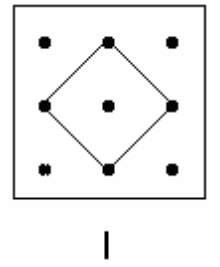


Let us have a closer look at the solution of this type.

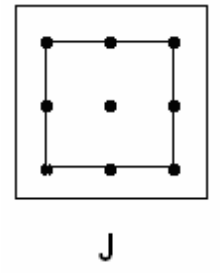
a) How many rectangles have their shortest side at the length of a?



b) How many rectangles have their shortest side at the length of *b*?



c) How many rectangles have their shortest side at the length of *c*?



č) How many rectangles have their shortest side at the length of d?

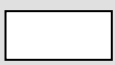
There is no such rectangle.

d) How many rectangles have there shortest side at the length of *e*?

There is no such rectangle.

By using the strategy of the shortest side pupils quickly discover that there are ten rectangles on the geoboard 3×3, among which 6 are squares and 4 are rectangles, and also that all four rectangles are congruent among them, which applies also to 4 squares out of 6.

Pupils can display all non-symmetrical rectangles in a table:

	Sides Lengths
A	*a*, *a*, *a*, *a*
B	*a*, *a*, *c*, *c*
I	*b*, *b*, *b*, *b*
J	*c*, *c*, *c*, *c*

3rd way: They search for rectangles so that they first look for all the rectangles which are also squares and then all the rectangles which are not squares.

Only after pupils have acquired enough experiences in solving problems of the second category they are introduced to the third category of problems with open path and open aim.

3.3 Problems with open path and open aim



This time we have changed the previous geometrical problem with open path and closed aim into a problem with open path and open aim.

Example 4: *Study rectangles on the geoboard* 3×3.

We can immediately see that this problem differs a lot from the previous two problems and from the problems we pose to pupils in the instruction of mathematics. We could denominate such a problem as

"problem-research" and we call the method we imply for solving it "research".

The principal objective in such problems is not the understanding of concepts, repetition of learning material and different procedures, as it is the case in the first and second category of problems, but to acquire knowledge for dealing with problem situations. Most of all we are trying to train pupils to think independently in new situations, of course at the level they are capable of. This requires the ability of setting a starting point and final aims by using simple tools for structuring and by using the capabilities of searching for regularities and rules in a transparently structured set. We therefore speak of basic and simple problem knowledge (Magajna, 1997, pp. 16-23).

Some different ways of research/study that pupils chose when working on this problem were as follows:

Example 4.1: Pupils decided that their aim would be to calculate all the perimeters and areas of all different rectangles on their 3×3 geoboards and then sort them according to their perimeter or area size.

Example 4.2: Pupils decided to arrange rectangles according to their nature (»the diagonals are perpendicular between them«).

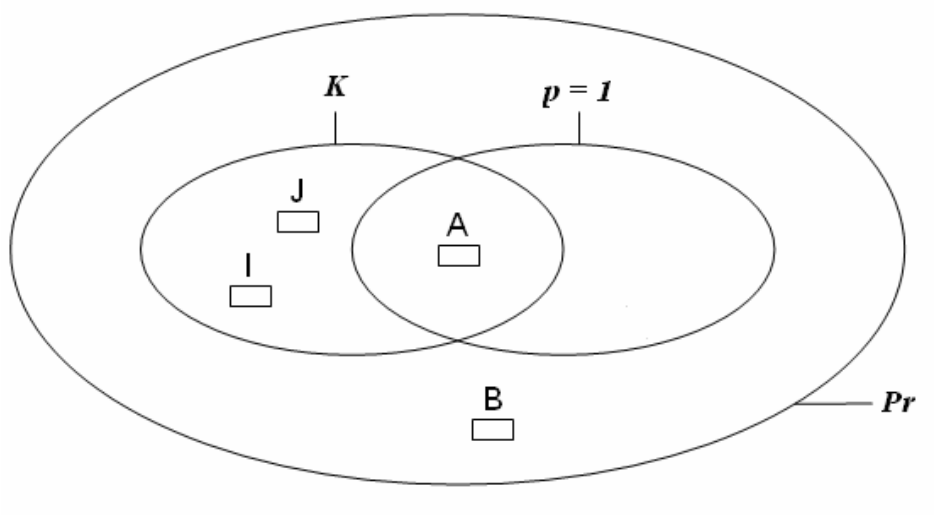
Example 4.3: Pupils decided to arrange the rectangles that they found on the 3×3 geoboard according to the following two characteristics: »it is a square« and »the square area is one square unit«. Afterwards they would present the arrangement in various displays.

For the problem of arranging it is very important that pupils learn how to use different displays. This way, pupils can solve a problem in a way that they understand and consider the most suitable.

Let us have a look at the Example 4.3.

1st way: display with Euler-Venn's diagram

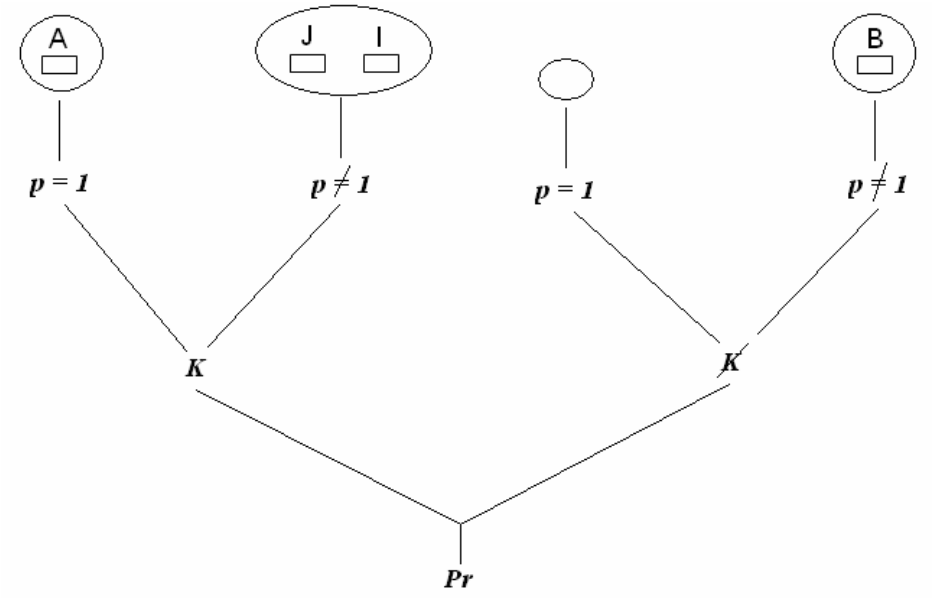
We mark '***Pr***' the set of all different rectangles on the 3×3 geoboard, '***K***' the set of squares and ***p = 1*** the set of all rectangles with the square area equal to one square unit.



2nd way: display with Carroll's diagram

	K	K̸
p = 1	A	
p ≠ 1	J, I	B

3rd way: display with a tree diagram



Pupils are supposed to comment in class one the use of the different diagrams (What are the advantages of each of them? What are the disadvantages? Where are the differences? What do they have in common? Which one do you find the "the simplest" and the "easiest"? Why? Which one is most effective? Why?)

4 Empirical part

4.1 The purpose of the research

In order to recognise, understand and use geometrical concepts and to solve geometrical problems, it is necessary to implement concrete didactic instruments. Among the most useful and well known in geometry is the geoboard, which helps us to visualise basic mathematical concepts. In Slovenia it has only been used in the recent years and only in certain schools, and therefore our research focused on the so called "problem-oriented instruction of geometry" with the use of the geo-panel.

Visualisation is extremely important for learners as it enables proper understanding of geometry by establishing links between the correct images and geometry concepts. For the instruction of mathematics the concrete-experience level is one of the obligatory stages in the development of cognitive processes, and we should use different didactic tools to support this.

In our study we aimed to show that by using the geo-panel, pupils are very successful in mastering basic geometry concepts and develop a problem-solving attitude towards geometry. The geoboard enables them to both solve closed geometry problems as well as to research open geometry problems. The results of the study are mainly supposed to contribute to the development of problem-oriented geometry instruction with the use of geoboard for the concepts of geometrical figure, vertex, sides, angles and congruency.

4.2 Research hypotheses

General research hypothesis

The pupils of seventh grade of the nine-year primary school who participate in problem-oriented geometry instruction with the use of geoboard are more successful in solving geometrical exercises than the pupils who are being taught using the traditional transmission approach without the use of geoboard.

Specific research hypotheses

H1: There will be significant differences in recognising and understanding the basic geometry concepts between the experimental group (EG) and the control group (CG).
H2: There will be significant differences in the use of procedures between the experimental group (EG) and the control group (CG).
H3: The experimental group (EG) will be more successful in solving simple and more complex geometry problems than the control group (CG).

4.3 Research methodology

Principal research method and approach

In the research we used the causal experimental method since it is suitable for studying »novelties« (the geoboard) which are being introduced into instruction.

Experiment Model

We planned the one-factor experiment model with school grades as comparable groups with two modalities. The seventh grade classes at different primary schools of the Littoral-Karst area of Slovenia functioned as comparable groups. Prior to the experiment we did not do any balancing of classes towards accidental differences, i.e., there had been no randomisation.
The group of pupils where we introduced the experimental factor was called the experimental group (EG), and the group of pupils with no experimental factor was called the control group (CG). Six teachers were included in the experimental group (EG).

For the experimental group a complete experimental treatment was applied including problem-oriented geometry instruction with the use of geoboard for teaching and learning basic geometry concepts such as figures, angles, sides, vertex and congruency. The control group used the traditional didactic tools.

Sample

We included into our research 113 pupils, of which 62 pupils coming from 2 primary schools were the experimental group (EG) and 51 pupils from two other schools were the control group (CG).

Variables

Independent variables
The experimental factor functioned as the independent variable.

Dependent variables
All variables used to verify the knowledge in the experimental group (EG) and in the control group (CG) were dependent variables, i.e., the

results of children in geometry at various levels of knowledge according to Gagne's taxonomy:

- results in recognising and understanding geometry concepts,
- results in the use of procedures,
- results in solving simple problems,
- results in solving more demanding problems.

Procedure and data collection

The research took place in four phases in the school year 2009/2010.

Table 1. Presentation of the course of research.

Phase 1	Preparation of materials for teachers. Formation of the experimental and control group of teachers.
Phase 2	Preparation of the experimental group teachers for the experiment.
Phase 3	Pre-testing both groups of learners before the introduction of the experimental factor.
Phase 4	Introduction of the experimental factor into the experimental group.
Phase 5	Post-testing (testing of knowledge at the end of the experiment) in both groups.

The initial and final knowledge of geometry contents in the experimental and control group was verified by and initial and a final test of knowledge, which were designed specifically for the purpose of the research. In their production, we took into account the current curriculum and the objectives determined in it.

According to Gagne's taxonomy of levels of knowledge the tasks were divided into:

- recognition and understanding of geometry concepts (I),
- use of procedures (II),
- solving simple problems (III) and
- solving more demanding problems (IV).

Each of the two tests contained 7 tasks.

Data processing

In order to find out the differences in the knowledge of mathematics at all the knowledge levels between the pupils of the experimental and

control group at the beginning of the experiment we implemented the t-test; and in the desire to have a more objective analysis we included at the end of the experiment the analysis of covariance with one single co-variable (results of the initial test).

Results and interpretation

We interpreted the results according to the requirement of transparency and clarity as well as to the logic of proving the preset hypotheses. Each interpretation of results is equipped with a table. For the verification of hypotheses we followed the rule that the highest possible risk to reject the hypothesis was a 5 % error.

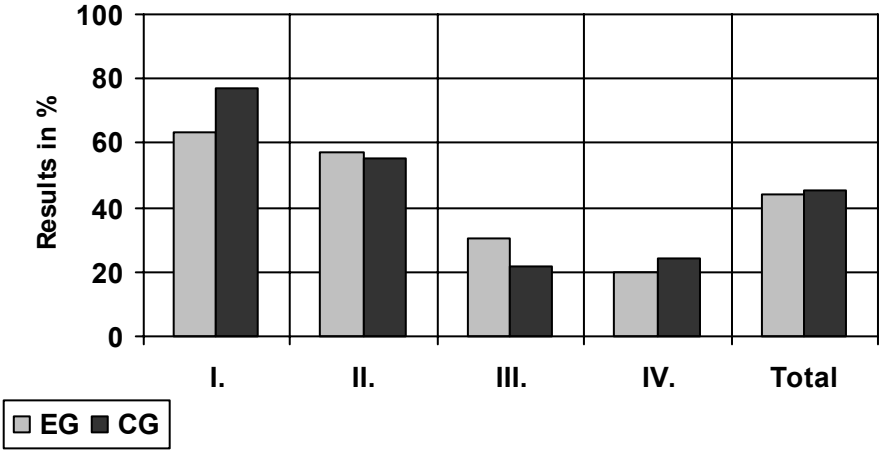
Let us analyse the differences in the knowledge of geometry at all four taxonomic levels of knowledge between the pupils of the experimental (EG) and the control group (CG) before the beginning of the experiment.

Table 2 covers all arithmetic means and the standard deviations of the initial test at the four taxonomic levels of knowledge (recognition and understanding of geometry concepts (I), the use of procedures (II), solving simple problems (III), solving more demanding problems (IV)) as well as joint results of the experimental (EG) and control group (CG).

Table 2. Basis statistic parameters of the initial test in geometry at four taxonomic levels of knowledge and the total results of the pupils of EG and CG.

Pupils' results (initial test)					
Knowledge level	Group	N	Arithmetic mean	Standard deviation	Results in %
I.	EG	62	5,05	1,65	63,10%
	CG	51	6,18	1,32	77,21%
II.	EG	62	8,03	3,44	57,37%
	CG	51	7,74	3,87	55,32%
III.	EG	62	3,02	2,15	30,16%
	CG	51	2,20	1,97	21,96%
IV.	EG	62	1,58	2,21	19,76%
	CG	51	1,92	2,50	24,02%
TOTAL	*EG*	*62*	*17,44*	*7,76*	*44,19%*
	CG	*51*	*18,04*	*7,74*	*45,10%*

The following histogram shows the results in geometry in % at all four levels of knowledge.



Graph 1. Pupils' results in % at four taxonomic levels between the EG and CG before the beginning of the experiment.

As we can see, there are some differences in the initial stage between the experimental and control group. The experimental group had better results at the 2nd and 3rd taxonomic levels, while the control group did considerably better on the initial test at the 1st level and slightly better at the 4th level.

A t-test was applied to verify whether those differences between the experimental and control group were statistically significant.

Table 3. Demonstration of differences at all four taxonomic levels of knowledge between the pupils of EG and CG (t-test) on the initial test.

Taxonomic levels	t	Degree of freedom	Level of statistical significance	Mean difference	Standard error
I.	-4,029	110,922	0,000	-1,128	0,286
II.	0,418	111	0,677	0,287	0,687
III.	2,097	111	0,038	0,820	0,391
IV	-0,769	111	0,444	-0,341	0,443
TOTAL	*-0,245*	*111*	*0,807*	*-0,362*	*1,474*

Based on the value of the t-coefficient and the level of statistical significance of the t-coefficient we can see in which variables the results between the EG and CG are statistically significantly different. The analysis of those results shows that statistically significant differences in favour of the CG appear in recognition and understanding of the basic geometry concepts (I). Statistically significant differences were also noted in solving simple problems (III) in favour of the EG. The results of arithmetic means showed that there were no significant differences in the use of procedures (II) between the EG and CG or in solving more demanding problems (IV), which was indirectly proven by the t-test as well.

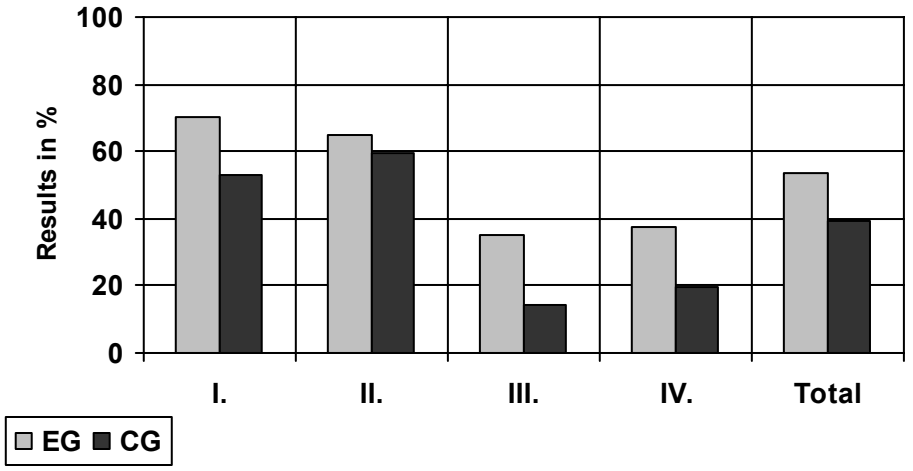
On the basis of the results above we can conclude that the EG and CG were quite different at certain taxonomic levels, but the total result shows that there are no major differences between the groups in the knowledge of geometry contents.

Let us analyse the differences in the knowledge of geometry at all four taxonomic levels of knowledge between the pupils of the experimental (EG) and the control group (CG) at the end of the experiment.

The table below covers the arithmetic means and the standard deviations at four taxonomic levels at the final test of knowledge.

Table 4. Basic statistic parameters of the post-test at four taxonomic levels of knowledge and the total result of the EG and CG.

Pupils' results at the first level of knowledge (post-test)					
Knowledge level	Group	N	Arithmetic mean	Standard deviation	Results in %
I.	ES	62	5,61	1,94	70,16%
	KS	51	4,22	1,83	52,70%
II.	ES	62	8,45	3,54	65,01%
	KS	51	7,73	3,78	59,43%
III.	ES	62	3,18	3,39	35,30%
	KS	51	1,29	2,43	14,38%
IV.	ES	62	2,65	2,23	37,79%
	KS	51	1,37	1,54	19,61%
TOTAL	*ES*	*62*	*19,89*	*9,05*	*53,57%*
	KS	*51*	*14,61*	*7,74*	*39,48%*



Graph 2. Pupils' results in % at four taxonomic levels (EG vs. CG) after the experiment.

If we compare the differences in the results of the EG and CG, we can see that the EG was more successful in solving geometry problems at four taxonomic levels of knowledge even up to 20 %.

Let us also see if the results differ statistically significantly between the EG and CG (t-test).

Table 5. Presentation of differences at all four taxonomic levels of knowledge between the pupils of EG and CG (t-test) on the post-test.

Taxonomic levels	t	Degree of freedom	Level of statistical significance	Mean difference	Standard error
I.	3,916	111	0,000	1,397	0,357
II.	1,052	111	0,295	0,726	0,690
III.	3,436	109,09	0,001	1,883	0,548
IV	3,576	107,824	0,001	1,273	0,356
TOTAL	*3,290*	*111*	*0,001*	*5,279*	*1,605*

From the table above (Table 5) we can see that the groups differ statistically significantly at the 1st, 3rd and 4th taxonomic levels. From the table of basic statistic parameters (Table 4) and from the t-test (Table 5)

we can see that the EG also did better on the tasks where the pupils had to use procedures (2nd level of knowledge), but the difference between the groups was not statistically significant.

On the basis of the obtained results and their analysis we can confirm the first specific hypothesis (H1):
There will be noticeable differences in the recognition and understanding of basic geometry concepts between the experimental group (EG) and control group (CG).

It has become clear that pupils who participated in problem-oriented instruction with the use of the geo-panel recognised and understood geometry concepts such as figure, side and angle much better than the pupils in the control group.

From the table of basic statistic parameters (Table 4) and from the t-test (Table 5) we can understand that the EG also did better on tasks where they had to use procedures (2^{nd} level of knowledge), but the difference between the groups was not statistically significant. Traditional geometry instruction is more directed towards mastering procedures which are most commonly used without pupils' understanding the concepts.

On the basis of the obtained results and their analysis we reject the second specific hypothesis (H2):
There will be noticeable differences in the use of procedures between the experimental group (EG) and control group (CG).

As we have already seen, the EG solved the geometrical problems much better and the difference between the groups was statistically significant. Let us check whether the differences between the EG and CG were also statistically significantly different in the case of simple geometry problems and in the case of more demanding geometry problems.

Table 6. Basic statistical parameters of the final test of the pupils' knowledge of simple and more demanding geometry problems from the EG and CG.

Pupils' results at the fourth level of knowledge (final test)					
Geometry problems	Group	N	Arithmetic mean	Standard deviation	Results in %
Simple (V7)	EG	62	1,60	0,155	40,70%
	CG	51	1,16	0,154	36,73%
More demanding (V6)	EG	62	1,48	0,226	35,62%
	CG	51	0,39	0,148	21,20%

Table 7. Presentation of differences in the knowledge of simple and more demanding geometry problems between the pupils of the EG and CG (t-test) on the post-test.

Geometry problems	t	Degree of freedom	Level of statistical significance	Mean difference	Standard error
Simple	2,011	110,007	0,047	0,440	0,221
More demanding	4,036	101,805	0,000	1,092	0,271

When comparing the differences in the results in basic statistical parameters (Table 6) and the results of the t-test (Table 7) in solving simple geometry problems on the post-test, we can see that the EG was more successful by slightly less that 4 % and that the differences are statistically significant. In case of more demanding geometry problems the differences between the EG and CG are statistically significant as well, and higher results were achieved, as expected, by the EG (up to 14 %).

From the above analysis we can confirm specific hypothesis H3:
The experimental group (EG) will solve simple and more demanding geometry problems more successfully than the control group (CG).

In order to further increase the objectivity of the results we also used analysis of variance. For the analysis of the end-results it is namely decisive whether, in reference to the control variables, the EG and CG do not differ between them too much. If the groups are not equal, we cannot attribute the differences at the end of the experiment only to the impact of the experimental factor (the geoboard), but also to the

influence of the unbalanced initial stage of both groups. The analysis of co-variance statistically eliminates the influence of different positions of the EG and CG.

Table 8. Test of co-variance in the final stage after the initial stage results partialisation.

Variance source	Sum of squares	Degree of freedom	Medium square deviation	F	p
CO-VARIABLE					
Initial test	3,04514	1	3,04514	120,46	0,0000
Groups (EG and CG)	0,638275	1	0,638275	25,25	0,0000
REMAINDER	2,78069	110	0,025279		
TOTAL	6,40249	112			

Co-variance analysis shows that the differences in the initial test between the EG and CG are statistically significant. Despite those differences and taking them into account in the analysis of the final test, a statistically significant difference appeared between the groups in the final stage.

On the basis of all the obtained results and their analysis we can conclude that the model of problem-oriented geometry instruction in which pupils used the geo-panel was very successful. Hence, we can confirm our general research hypothesis:
The pupils of seventh grade of the nine-year primary school who participate in problem-oriented geometry instruction with the use of geoboard are more successful in solving geometrical exercises than the pupils who are being taught using the traditional transmission approach without the use of geoboard.

5 Conclusion

In the experiment described in this paper, developing new geometry concepts by solving and studying geometry problems was based on concrete problem situations on the geoboard. This way, pupils were intrinsically motivated for solving and studying geometry problems and made an effort to employ all their abilities. Intrinsic motivation generally comes from inner tensions – curiosity, interest in the problem and therefore from the joy of active solving and, when successful, is marked by a sense of achievement.

Those aspects, linked with the reality and concreteness of a problem, are directly connected with the definition of a problem: a problem involves intellectual searching and evokes cognitive tension which pupils have to experience in the context of the problem situation. So, pupils studied and discovered the nature of geometry concepts and objects, recognised and understood new geometry expressions, solved various types of problems and used and combined the acquired knowledge. Only that way we can develop in pupils geometry thinking. Geometry occupies a very important place in mathematics, because, as stated by Usiskin (1990), it:

- enables research work in the physical world,
- deals with visualising, drawing and constructing figures,
- gives the possibility of representing mathematical concepts which by themselves are not visual,
- is by itself an example of a mathematical system and
- gives us pleasure and is aesthetic, added Willson (1977).

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APPROACH TO DEVELOPING THE LEARNING TO LEARN STRATEGY IN CHEMISTRY

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ABSTRACT

Students need to develop learning strategies in chemistry soon enough in order to be able to challenge more demanding concepts in chemistry as they progress along the educational vertical from elementary to secondary school and university. Different strategies can be applied to chemistry teaching with the aim of encouraging students to learn chemistry at the macro, submicro and symbolic levels. In this chapter the *GALC* (*Guided Active Learning in Chemistry*) strategy is described. Every strategy has a different impact on developing the students' learning strategies. When students use the *GALC* approach they learn new concepts and connections between them in groups within the social context. The *GALC* approach is more appropriate for students in the school environment than at home, as it assumes group learning. It is crucial to implement these strategies in Slovenian schools in the near future and to try to evaluate them in view of their contribution to the development of the students' competences needed for the learning to learn strategy in chemistry.

KEY WORDS: Chemistry education innovations, Learning to learn, The GALC strategy, Active chemistry learning

1 Introduction

Research shows that there is a lack of evidence that traditional lectures as well as traditional laboratory activities (Tobin, 1990; Lazarowitz & Tamir, 1994; Hofstein & Lunetta, 2004) in chemistry lessons contribute to promoting meaningful learning. Innovative learning strategies could be

used by teachers at all levels of chemistry education to enhance the students' motivation to learn chemistry (Hanson & Wolfskill, 2000; Eybe & Schmidt, 2004). One of such innovations is the *GALC* (*Guided Active Learning in Chemistry*) strategy, which is presented in this chapter. This approach can be used by teachers in order to facilitate learning to learn strategies in students, who can apply them in the future when learning about new chemical phenomena described by more abstract concepts.

Learning to learn can be defined by the Campaign model, which describes 'learning to learn' as a process of discovery about learning. It involves a set of principles and skills which, if understood and used, help learners learn more effectively and be involved in life-long learning.

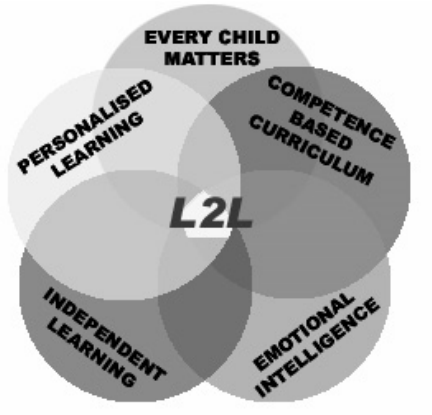


Figure 1. Learning to learn (L2L) model (http://www.campaign-for-learning.org.uk/ accessed, 10.6.2010)

This model assumes that learning is learnable and different aspects (such as: every child matters, personalised learning, independent learning, emotional intelligence and a competence based curriculum) should be considered to reach that goal. Learning to learn raises the students' awareness of: (1) their preferred mode of learning and of their learning strengths; (2) their prime motivators and self-confidence to succeed; (3) the issues they should consider, such as the significance of water, nutrition, sleep and a positive learning environment; (4) some of the specific strategies they can use, for example, to stimulate their memory or to make sense of complex information, and (5) some of the

habits they should develop, such as reflecting on their learning, so as to achieve improvement in future.

Learning chemistry reveals some specific aspects, especially because chemistry (and other scientific) texts exhibit special characteristic features that need to be taken into account while studying them. Students need to consider the following essential points of each learning period: (1) the learning period should not exceed much more than one hour without a break; (2) the first five minutes should be used to review the topic learned last time, which is relevant to the present work; (3) concentration in the learning process is the most important factor, (4) a particular goal should be set for the current period of study; (5) at the beginning the content of the current topic should be skimmed, so that the learner gets acquainted with the gist and the potential problems which might be encountered during learning; (6) the content should be read out slowly and in detail; (7) the content should be presented in a different manner, e.g. by flow charts, diagrams, lists, mind-maps, concept maps etc; (8) the topic should be skimmed again in order to get a more detailed overview, adding knowledge to the previous information; (9) the process of knowledge testing is important; (10) assessing the understanding of the concept is crucial and, if needed, the learner should revise the difficult points; and (11) a few days later the content should be skimmed again to reinforce the learning (http://home.clara.net/rod.beavon/learning.htm).

Developments in cognitive learning theories and classroom research show that students generally experience improvements in learning when they are engaged in classroom activities that encourage developing their own knowledge following a learning cycle (Farrell et al, 1999). Students need to work together, not only because of their preparation for team work (in science and most of the professions), but because they learn better through social interactions. Students should reach their own conclusions and not be called upon to verify, for example, what the textbook or instructor has indicated to be the expected result of the experiment,. The student must be an active learner (Spencer, 1999; Hanson & Wolfskill, 2000).

2 Guided active learning in chemistry (*GALC*)

The *GALC* approach, which was developed in line with the above assumptions, was based on the *POGIL* (*Process Oriented Guided Inquiry Learning*) pedagogical method, the purpose of which was to teach process skills (such as collaboration and written expression) as well as the content using the inquiry based approach (Farrell et al, 1999; Hanson & Wolfskill, 2000; Hanson, 2007) and the theories on cooperative and collaborative learning. This method was developed in the USA for use in teaching general chemistry, but POGIL can be applied to teaching other subjects, as well. Because this chapter is not dedicated to *POGIL*, this method will not be described in detail. You can get more information on *POGIL* at its official webpage: http://new.pogil.org/ and in some other references, such as in the paper published by Minderhout & Loertscher (2007). *POGIL* and *GALC* are both based on the guided inquiry approach to learning and on the constructivist principle; i.e. it is assumed that students learn better if: (1) they are actively engaged and thinking in the classroom; (2) they develop knowledge and reach conclusions themselves by analysing the data and discussing ideas; (3) they learn how to understand concepts and solve problems together; (4) the teacher adopts the role of facilitator to assist groups in the learning process; and if (5) the teacher does not provide answers to any questions, so that the students are reasonably expected to provide answers themselves (Farrell et al, 1999).

The difference between *GALC* and *POGIL* is in the organisation and adaptation of the *POGIL* method to the Slovenian 45-minute periods of lessons. The *GALC* learning units can be used by the teacher in the classrooms during one learning period and are adapted to serve the teacher according to the standards and competences set by the national curriculum. Another significant difference is also in experimental work, which is incorporated into the *GALC* learning unit. This approach is not characteristic for the *POGIL* method. Other segments of the *POGIL* and *GALC* units are similar.

Guided active learning in chemistry (*GALC*) tries to establish the active learning environment in the context of group work through cooperative learning. Four students in a group organise their work by themselves, which is directed by the worksheets with text, models and tasks at

different cognitive levels. The materials are adapted to the students' knowledge level for a certain grade.

GALC also indicates the significance of the reversed teaching process, in which teaching and learning is no longer teacher-oriented, but learner-oriented. *GALC* is based on the findings that ex cathedra teaching does not suffice for the majority of students any more, and that those who participate in the interactive peer groups have greater opportunities for profound knowledge acquisition. Another important aspect takes account of the fact that knowledge is personal, which means that students take greater interest in learning, that they adopt a more favourable attitude to the content to be studied, thus taking every opportunity to understand the meaning of individual concepts integrated into logical units (Hanson, 2007).

It is important that those students who are exposed to work with the *GALC* learning units tend to delve into the contents if they can actively participate in the learning process more profoundly and they also understand them better, thereby contemplating about the content to be studied and learning to work in a team (usually composed of four students). Their knowledge is developed by the data analysis and the discussion on ideas pertaining to the learning content. Attention is also paid to written and verbal communication and to team work. Consequently, the individual concepts within the content are easier to understand, and students also develop problem solving abilities. Further, it is established that a team work environment, in which research methods are applied, motivates students and enables the teacher to be provided with immediate and permanent feedback on the students' comprehension of the discussed concepts and their connections and on the potential misunderstandings, as well. Such a work method contributes to raising the students' awareness of logical thinking, developed within group work, and is also an important aspect of learning apart from producing the right answers in collaboration with group members. Further, such work fosters team learning, as the learning process involvs much more than just memorising facts, it is an interactive process of changing the contemplations on concepts and developing the specific skills of each student. The metacognitive process is crucial in the *GALC* approach to teaching chemistry, enabling the students to be aware of the learning process through self-reflection, self-evaluation, self-planning and self-regulation of the educational process.

Thus *GALC,* similar to *POGIL,* creates a learning cycle with the students' activities, comprising exploration, grasping the new concepts by their understanding and the application of the gathered knowledge to new situations. In this process the teacher's role is only to be a facilitator, providing assistance to the students in the learning process.

GALC is devised similarly to *POGIL*, although the learning units are somehow differently structured. Students examine the chemistry contents through the learning unit which wraps up a certain learning content, either independently within the group or with the teacher's assistance when needed (by providing extra questions, but not answers to them, with a view to directing the thinking process within the group). Each group consists of four or five members with each of them being assigned a certain role, e.g. the leader, the recorder, the spokesperson and reflector(s). The students decide unanimously on their respective roles, which are different regarding the learning units, i.e. a particular student adopts a different role in various *GALC* learning units.

3 The structure of the *GALC* learning units

The learning units have their specific parts, which follow consecutively and guide the student through the learning unit. At the end of each learning unit the students should be able to solve problems in connection with the learning content discussed. The specific parts of the learning unit are, as follows: (1) Title, (2) Why do I have to I learn this?, (3) Learning goals, (4) Learning outcomes, (5) Prerequisites (6) Additional resources, (7) New concepts, (8) Information and models, (9) Key questions, (10) Exercises, (11) Do I understand?, and (12) Problems.

In continuation, the *GALC* learning unit comprising every stage of the student's work is presented. In this unit the students get acquainted with the substances - crucial nutrients for human beings, which are mostly acquired through foods of animal origin.

Each learning unit *title* is set as a problem question, mostly referring to the concrete environmental situation, with which students are more or less familiar, so that the title addresses the specific context. In this particular case the nutrition of the humans is addressed, which should

also comprise proteins as fundamental components of every living cell; proteins of animal origin contain most diverse amino acids.

3.1 The title of the *GALC* learning unit

Which substances are consumed mostly with the intake of meat, eggs or milk?

In the next stage, students are first presented with the reasons for studying the particular chemistry learning content and for the understanding of the concepts defining it. Thus, the part *Why do I have to learn this?* deals with the content of the learning unit in a wider context, implying the plausible answers to the question posed in the title. The text of this part should be interesting for the students in order to arouse their interest in further delving into the learning unit. It is crucial that the context in which the particular learning unit is placed, is already presented in this part.

3.2 "Why do I have to learn this?" chapter in the *GALC* learning unit

Proteins account for appr. 50 % of the total cell dry mass and are most complicated biological macromolecules regarding their structure, with each of them building its own significant structure and its own function. For this reason the knowledge on the molecular structure of proteins is crucial for the students' further understanding of chemical processes in organisms, and consequently, for healthy food recommendation .

The chapters *Learning goals* and *Learning outcomes* are placed prior to the concrete activities that students are to pursue before they reach the set goals of a particular learning unit. The learning goals comprise the description of the content to be learned and are in line with the goals of the national curriculum for chemistry and with the competences to be gained by the students when they have reached a certain level of education. The teacher can also use the proposed learning outcomes for devising own knowledge tests.

3.3 "Learning goals" and "Learning outcomes" in the *GALC* learning unit

Learning goals

- *To realise the significance of proteins for humans*
- *To get to know the basic building blocks in proteins*

Learning outcomes

- *To identify the formula for a protein molecule*
- *To understand the chemical structure of an amino acid molecule*
- *To get know some of the characteristic properties of amino acids*

The following three chapters are divided into: (1) *Prerequisites* composed of the very concepts and learning contents, respectively, that are crucial for the students to understand new concepts, models and data, that are stated in the continuation of the new learning unit; (2) *Additional resources* providing for the additional resources or literature, respectively, in which students will be able to find additional information on the discussed learning content; and (3) *New concepts* that students will be presented with in the learning unit are enumerated in this chapter without their specific definitions.

3.4 "Prerequisites", "Additional resources" and "New concepts" in the *GALC* learning unit

Prerequisites

- *To get know the basic structure of organic molecules*
- *To get know some basic functional groups of organic molecules*
- *To get know the basic rules of symbolic language in chemistry*

Additional resources

In case of difficulties in problem solving you are advised to consult the chemistry textbook for 9th grade of elementary school and the internet

New concepts

proteins, amino acid molecule, essential

In the *Information and Models* chapter, groups of students begin with concrete work within the learning unit, consisting of careful reading and discussing the chapter with other group members. In this part of the learning unit the learning content is presented and students are empowered to look for answers to the questions posed in the next parts of the learning unit. However, in this case the models do not refer to physical models, submicrorepresentations or any other models one

encounters in chemistry, but to models leading to contemplations about the new concepts, such as various pictures, charts, symbolic notes, etc. on the basis of which students learn new concepts and the connections between them. In this example only some data pertaining to the learning unit are enumerated, as this unit contains a lot of text irrelevant for this particular example.

3.5 "Information and Models" in the *GALC* learning unit

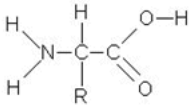
Information and Models

When we discuss proteins, meat, eggs and milk are usually referred to. These foods of animal origin are the most important protein sources of our nutrition. One egg contains appr.7 g of proteins, one glass of milk 8 g and one steak weighing 8.5 decagrams over 20 g of proteins. Further, proteins are also contained in legume plants, corn and seeds. 6 to 10 g of proteins are contained in appr. 90 g of lentils, soya beans, peanuts or beans. Also bread, noodles and rice can be counted among important protein sources. Although plant proteins are less utilized in protein building in the human body than animal proteins, diverse plant nutrition can meet the needs for human proteins and consequently for amino acids, as well.

In Mexico, for instance, the main protein sources are beans and rice, in India lentils and in China soya beans.

... the learning unit comprises more information at this point…

Model 1. All amino acids have the same general formula.



Eleven amino acids are considered non-essential, meaning that the adult body is able to adequately synthesize them, whereas nine are considered essential, meaning that the body is unable to adequately synthesize them, so they should be supplied through the suitable protein foods. The amino acid molecules are distinguished by the fourth variable substituent, the R-group, which can be a chain of different lengths or a carbon-ring structure.

Table 1. In the table amino acids, bonded to the proteins in organisms, and their abbreviated symbols are presented.

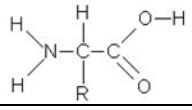
Essential amino acids		*Non-essential amino acids*	
Histidine	*His*	*Alanine*	*Ala*
Isoleucine	*Ile*	*Arginine**	*Arg*
...	...	...	...

... the learning unit comprises more information and more models at this point…

The answers to the *Key questions* comprise the very pieces of information which are provided in the *Information and Models* chapter, thus again leading the students to more detailed reading and mutual discussion on the topic of the *Information and models* chapter. When looking for answers to the key questions the students are to analyze the data and establish connections among them and evaluate the syntheses. By doing this the students reach higher cognitive levels themselves. Through the questions posed the students arrive at important concepts and connections among them, thus developing their understanding. This is the lowest level of task solving, because students are more or less expected to mainly reproduce data. Sample questions from the learning unit on proteins are provided below.

3.6 "Key questions" in the *GALC* learning unit

1. *. Are diverse plant foods sufficient for regular functioning of an adult organism? Justify your answer.*
2. *Which plants contain proteins with essential amino acids, needed for a balanced nutrition for humans?*
3. *What do proteins of plant origin and of animal origin have in common?*
4. *What does the word* **essential** *stand for with regard to food proteins?*
5. *Enumerate the essential amino acids for an adult and their abbreviated symbols.*
6. *Do all plant proteins contain every essential amino acid for humans? Justify your answer.*
7. *Below is a general formula of an amino acid. In the formula mark the significant groups and write down their names.*



The gathered knowledge of the specific learning content is afterwards applied by students at solving more simple tasks in the *Exercises* chapter. This work contributes to developing the students' self-confidence in applying new knowledge. The *Exercises* chapter is upgraded with the *Do I understand* chapter, in which students provide answers to a series of questions, thereby adding to their knowledge and establishing their comprehension of the learning unit topic. This chapter is mainly devoted to the metacognitive process and continues with the last, most demanding learning stage, i.e. problem solving tasks.

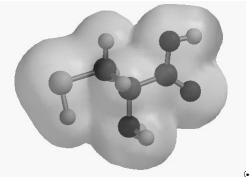
3.7 "Excercise" and "Do I understand?" in the GALC learning unit

Excercise

1. *Write down the structural formula of the amino acid with the Ala sign, if you know that the methyl group is bonded to the central carbon atom. Mark individual groups in the molecular formula.*
2. *Analyze the structural formulas of the molecules of amino acids in the figure 1and write down the rational formulas of those molecular parts that distinguish one amino acid from other amino acids. Mark individual parts of amino acids with their abbreviated symbols.*

Do I understand?

1. *Which type of food, the one of plant or animal origin, contains more proteins? Which proteins, plant or animal, contain more diverse essential amino acids?*
2. *Write down the formula of glycine if you know that this is the simplest amino acid, which means that it does not contain any group with carbon atoms in its side chain.*
3. *In the picture there is the model of the cysteine amino acid. Write down the structural formula of the cysteine.*



The last stage is devoted to the *Problems* chapter, in which students solve the posed problem task by applying synthesis and evaluation of the acquired knowledge, transfer of the knowledge to the new context and specific strategies. The majority of the *GALC* learning units are designed also in such a way that students need to carry out simple experiments in order to complete tasks. It is important that each group of students disposes of its own set of equipment and chemicals, which have been prepared by the teacher and/or a technician in advance, in order to carry out experiments. When performing experiments students within a group follow the instructions that are provided on the work sheets of the learning unit and fill in the tables by describing their observations and conclusions and provide answers to the problem questions; in other words, students should look for the answers within the scope of the experiments performed. Below is the description of the experiment which is used in the learning unit on proteins.

3.8 "Problems" in the GALC learning unit

Protein content in the food samples is determined by the biuretic reaction.

a. *The experiment should be carried out using three substances (flour, powdered gelatine, sugar) and water.*
b. *A pinch of individual substances should be put in your test tube and test tubes should be appropriately marked.*
c. *5 ml of hot water should be added into each of them; test tubes should be firmly shaken.*
d. *Only 5 mL of water should be poured into the fourth test tube.*
e. *1 mL of a 10 % solution of sodium hydroxide in water and 3 drops of a 0.5 % copper sulphate should be added to all test tubes and firmly shaken.*
f. *Changes should be monitored and the observations written down in the appropriate table.*

Answer the questions using the experimental data

1. *What did you notice at the experiment in which you used water for the biuretic reaction? Why did you use water for the experiment?*
2. *Which samples contain proteins? What is your conclusion based on?*
3. *What is the evidence of the biuretic reaction?*
4. *Are there amino acids present in the food samples? Justify your answer.*
5. *What can you infer from the experiment with flour?*
6. *How is flour made?*
7. *What can you infer from the experiment with gelatine?*
8. *How is gelatine made?*
9. *What can you infer from the experiment with sugar?*
10. *How is sugar made?*
11. *Is it possible to infer from the experiment that foods of plant origin contain proteins? Justify your answer.*

4 GALC strategy implementation in the classroom

The teacher should approach the *GALC* educational strategy by introducing it verbally to all the students in the classroom. Once the new approach to work has been introduced, the teacher should form groups of students of four or five members each; within the groups the students take on the roles of the leader, the recorder, the spokesperson and the reflector(s) independently or per draw. The leader takes care of managing the group, so that every member equally participates in team work, discussions and in seeking solutions to the problems posed in the

learning units. In this process it is important that the leading of the group is based on the democratic principle. The recorder monitors closely the decisions of the whole group and, apart from noting down the solutions in the work sheets of the learning unit, he also protocols potential other findings of the team members, that could contribute to the process of studying the new learning content. The spokesman is the group member who draws up a short report (maximum 2 minutes) on the basis of the group performance and presents it to other groups. In the report mainly the potential problems encountered in the work with the learning unit should be put forward. The reflector's role is crucial as regards directing the activities by reading aloud the questions, to which the answers should be provided within the discussion of the group members. The leader of the group may also assign the role of the reader to other group members, so this role is taken over in turns by all the group members.

An individual *GALC* learning unit is devised to take appr. 35 minutes of students' group work, which should be taken into account by teachers in lesson planning. In case the students do not finish their work in the set time period, they can proceed in the next hour of lessons. Every student is presented with work sheets of the respective learning unit; the students first read the first chapter and then proceed from the first (*Title*) to the last chapter (*Information and models*) independently. Then the reflector reads out the first question in the ninth chapter (*Key questions*); in the discussion afterwards and rereading of the *Information and models* chapter, the group members brainstorm and try to find the most appropriate answer to the question posed. The reporter notes down all the relevant information and the findings put forward by the group members. When the answer is provided, everybody writes it down in the appropriate place in the work sheets. In such a manner a comprehensive discussion is organized within a group, triggered by the *Key questions* chapter. In this process the teacher monitors the work within groups. If the teacher's assistance is needed by individual groups, the leader of the respective group raises his hand to get the teacher's attention and to present him with the problem encountered; the teacher, however, does not provide the solution to the problem, but asks one or more rather simpler questions to facilitate the students' solution of the problem. When doing this the teacher tries to direct the reflections of the group members. Every question of the teacher is written down by the

reporter, so that in the continuation of learning the group members have the opportunity to reread each question and find the most suitable answer to it. In looking for answers to questions the students can also be assisted by the prescribed chemistry course book for a particular grade of primary school or they can consult the internet if there is a possibility to do that at school, when they come across difficulties. It is important that each group disposes of one computer and internet access and that the students are able to evaluate the obtained web information mainly from the viewpoint of its unobjectionability.

Once the group members have provided answers to every key question, they proceed in a similar way with doing other exercises in the *Do I understand* chapter and with solving problem tasks.

When all the groups have finished their work after appr. 35 minutes, each group reports for 2 minutes on the potential difficulties they have encountered at their work with learning units. The teacher guides the reporting and proposes possible solutions to the problems during team work.

In case the students have not finished their work in relation to the learning unit in the set time period, they continue with learning in the next chemistry lesson and the work is again finished with reporting, and additional knowledge consolidation of the new concepts and connections among them.

5 Conclusion

The prime goal of implementation of the *GALC* strategy in the chemistry lessons is to encourage pupils, secondary students and college students to build up their knowledge within a group (social learning context) in a guided manner through discussion and to attend to more or less demanding tasks. It is important to emphasise that such an approach to learning chemistry encourages students to deliberate more critically on the concepts that they are about to learn. All the students are active group participants in a specific area (reading, writing, experimenting ...) but their roles are changed in every lesson. When exposed to this strategy, students also develop their own knowledge. The results of the research on the *POGIL* implementation into the organic chemistry lab

work show that students achieve better results with the concepts that are considered to be more difficult or abstract (such as organic reactions mechanisms). Students are more confident at solving such problems and they also changed their views on the difficulty of the course during the semester (Schroeder & Greenbowe, 2008).

The implementation of the *GALC* strategy in the lessons and its planned evaluation is needed, with a view to establishing the impact of this strategy on the development of the "learning to learn" strategy with students. In this way more quality knowledge would be built up, also by understanding chemical concepts at higher educational levels when this strategy has no longer been pursued.

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CREATIVITY IN THE ZONE OF PROXIMAL MOTIVATIONAL DEVELOPMENT

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ABSTRACT

The main topic of the paper is the stimulation of creative thinking at school by understanding the dynamics of motivation that regulate pupils' learning behaviour. The socio-cultural paradigm of learning and teaching emphasises the importance of the learning context and/or the motivational role of pupils' active engagement in social interactions in the process of constructing knowledge, creating achievements and innovation. In the forefront there is the zone of proximal development, which encourages pupils to develop their potential through professionally premeditated individualisation. This encompasses two levels of the pedagogical approach, the cognitive and the motivational, which in the optimal proportion ensure pupils the conditions for activating their higher-level thinking processes, for quality learning, and thus also for the creative thinking that leads to innovative achievements. Therefore, there is a need for teachers to recognise the cognitive as well as the motivational potential of their pupils and to become more familiar with effective approaches to raising their pupils' motivation in the zone of proximal development, and thus to ensuring creative problem solving and an innovative process of achievement in different (artistic) areas.

KEY WORDS: Learning, Motivation, Yone of proximal motivational development, Creativity, Stimulating creativity at school

1 Introduction: Creativity in the Social Context

Creativity is a complex psychological phenomenon that can be defined, researched and/or understood from various perspectives - from the perspective of ability, thought and personality characteristics, as well as from the perspective of the process of learning and/or creative achievements (Makel and Plucker, 2008, Runco, 2004). Stimulating development and nurturing creativity in the learning or school context has an important value, as creative thinking as a form of complex thinking that can be systematically developed in school is closely connected with the quality of learning and problem solving, as well as with innovation and overall social development (Davis, 2003; Makel and Plucker, 2008; Runco, 2004; Poon Teng Fatt, 2000; Tan, 2007). It is precisely this issue that is addressed in the present paper.

By way of introduction it is worth first clarifying how to understand creativity. The fact is that in spite of the history of study and findings regarding the importance of the creative in various areas of human activity, not just in school, today there is still no unified definition of creativity. Various disciplines of psychology attempt to clarify what creativity is, with each discipline emphasising a particular aspect (Makel and Plucker, 2008). Thus the psychometric concept emphasises the various components, or the structure, of creativity, authors with a developmental orientation explain creativity from the point of view of developmental dynamics, while systems or context theories, in which the socio-cognitive aspects are emphasised, highlight factors that influence the development of creativity. Plucker, Beghetto and Dow (2004) meaningfully combine findings from all of the three above mentioned approaches in a definition that we will adopt for the purposes of the present paper, namely that creativity is "the interactive interweaving of abilities, processes and the environment, on the basis of which the individual or group realise an acceptable product, both original and useful, within a particular social context" (ibid., p. 90). Other context-oriented authors understand creativity in a similar way, and (significantly) amongst various factors emphasise the role of motivation for creative behaviour. Thus, for example, amongst four key factors for the development of creativity in addition to (internal) motivation Amabile (1996) includes cognitive, personality and social

factors, while Sternberg and Lubard (1996) add intelligence, knowledge, style of thinking, personality and the environment to the factor of motivation. Csikszentmihalyi (1999) also understands creativity as the dynamic interweaving of (1) cultural-social factors, (2) the field in which creativity appears, and (3) the individual's personality characteristics, amongst which he emphasises flow[16] as the central motivational characteristic; in the opinion of the author, without flow one cannot arrive at the creative process at all. Gardner (1993), Torrance (2004), Urdan (2007) and other authors also emphasise the individual's motivation as a personality characteristic that makes a key contribution to creativity.

2 The Role of Motivation in the Process of (Stimulating) Creative Thinking/Learning

Hennessey (2007) emphasises that in comparison with other factors of creativity, such as knowledge and skills in a particular field, motivation as one of the key factors of creativity is significantly more changeable in nature and dependent on the given situation or the concrete learning context, and it is therefore necessarily to devote particular attention to motivation. This is also confirmed by the findings of studies in which the relationship between motivational stimuli (internal motivation, reward, competition) and creativity has been examined. Pioneering research on the influence of motivational stimuli on artistic creativity was undertaken by Teresa Amabile in the early 1990s. In a classic experimental study the author examined the influence of competition on the visual art expression of girls and determined a negative effect; the visual art products of girls who were exposed to a competitive situation were significantly more modest than the products of their peers in a

[16] Csikszentmihalyi (Csikszentmihalyi, Rathunde and Whalen, 1993, p. 14) describes the experience of flow as "… a subjective state about which people report when they are entirely immersed in something that they take on from their own interest, to the extent that they forget about time and are unaware of their own efforts or of anything else that is not linked with the activity itself"; the author also explains that the experience of flow is not frequent, but under certain conditions we can achieve it in the majority of activities, both in play and in work or learning.

non-competitive situation (Amabile, 1982). On the basis of the study, Amabile proposed the principle of internal motivation for creativity, and explained that internal motivation (e.g., satisfaction, interest) leads to the creative process, while external stimuli (expectations, rewards) hinder this process. The principle was confirmed in later studies in various areas of pupils' artistic creativity – in the areas of language, visual arts, music and film (Amabile, Hennessey and Grossman, 1986; Eisenberger and Rhoades, 2003; Leung, 2008; Priest, 2006; Wolfe and Linden, 1991). Similarly, Conti, Collins and Picariello (2001) researched the influence of competition on creativity and the internal motivation of children for visual art activities while controlling the role of gender, and came to an even more precise conclusion; the authors undertook studies in which it was demonstrated that for the stimulation of internal motivation and creativity a key factor is the current social context, that is, the prevailing motivational predisposition of the group, most likely connected with the perception of the (male) gender role in the attitude towards competition; in artistic situations boys (in comparison with girls) even increase their creative power and motivation under competitive conditions.

In the last twenty-five years, a series of similar studies have been executed in which researchers have gradually developed and improved the research methodology. However, the basic results have nonetheless remained similar: motivational orientation either stimulates (when it is derived from the individual's internal attributes) or hinders (when it is derived from the individual's environment) creativity and creative learning (Sternberg, 2006); in this regard it is important to emphasise that the role of external motivation in stimulating creativity is positive in situations in which individuals receive positive feedback about their competence and when due to external stimuli the learning situation is more interesting (cf. Conti, Collins and Picariello, 2001), while it is negative in cases where the external stimuli represent a means of limitation and control, and the feedback about the creator's competence is negative (cf. Hennessey, 2007).

Research is fairly consistent in showing that motivation influences cognitive and metacognitive processes amongst pupils and thus stimulates higher forms of thinking and determines the individual's attitude and approach to learning and to activities that lead to (learning)

creative achievements (Jarvela and Niemivirta, 2001; Schunk and Zimmerman, 2008; Stipek, 1998).

Rheinberg (Rheinberg et al., 2000) explains the influence of motivation on learning more precisely, on three levels: (1) on the level of the time that the pupil dedicates to learning or to learning tasks, both in the sense of the extent (duration) and frequency of the execution of learning activities, (2) on the level of the forms, or nature, of the learning activities, which, on the one hand, is a case of balancing the effort that the pupil invests in learning (in relation to the level of difficulty of the learning task), while, on the other hand, concerns the use of learning strategies that will stimulate the pupil to learn and with which the pupil will effectively achieve his or her learning goals (superficial learning or learning for understanding), and (3) on the level of the pupil's functional disposition, which is based on the optimal psychological state of the pupil while learning, that is, the state of internal motivation in Csikszentmihalyi's sense; in this state learning proceeds in the most quality way (see Figure 1)

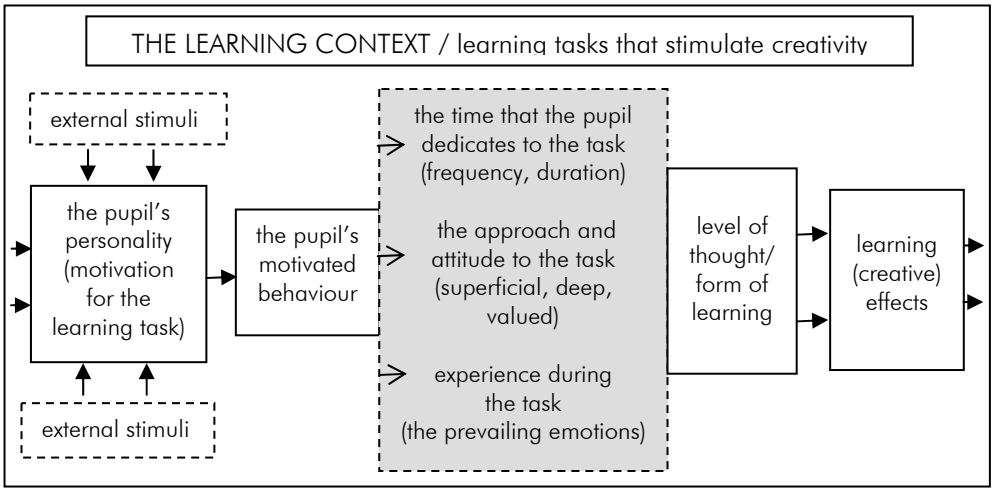


Figure 1. The dynamics of motivation in the process of creative learning (after Rheinberg et al., 2000).

3 The Motivation of Pupils for Creative Learning

For learning on the higher levels of thought, therefore also for creative thinking, which is distinguished by creative ideas, solutions, and artistic expression (Reber, 1995), according to the findings of Ryan and Deci (2000), it is possible to identity the well motivated pupil by the following key characteristics: (1) knowledge and learning represent an important value to the pupil within his or her value system, (2) the pupil is interested in everything connected with learning and with the mastery of learning skills – the pupil asks questions, seeks explanations, reads and converses, (3) the pupil wants to progress with his or her knowledge and learning competences, (4) the pupil believes that he or she can competently participate in the process of learning, and in the opposite case knows how to seek appropriate assistance, and (5) both momentary successes and failures in connection with learning encourage the pupil to persist in active participation in the learning process and in achieving learning results.

The fact is that not all pupils are motivated in the way described above, or are not (yet) internally motivated for learning. Their motivational orientation can also be external, which means that attributes of the environment, such as grades, rewards or social acceptance, encourage them to learn; it is equally possible that pupils experience learning passively and incompetently, developing negative emotions towards learning, and learning purely for instrumental or pragmatic reasons, in order to conclude learning as quickly as possible (Jurišević, 2006). It is therefore important that teachers, on the one hand, know how to recognise motivation or the motivational orientation of the individual pupils, while, on the other hand, also knowing how to stimulate pupils to learn and undertaken creative work with respect to their motivation; in the curricula there is a great deal of content that is unknown to the pupils and for which certain pupils demonstrate a complete absence of any kind of motivation.

4 The Motivation of Pupils for Creative Thinking

The professional competence of teachers for motivating pupils for creative behaviour on the basis of what has been outlined above presupposes complex professional knowledge with which the teacher must first recognise the actual motivational predisposition of individual pupils and then in the process of teaching modify or reinforce this predisposition, or establish it anew when the pupils first engage with a particular learning area (Jurišević, 2006). The teacher therefore has a dual role in any given school context, which can be defined on two interconnected levels: (1) on the level of learning content, as the retention and encouragement of the pupils' learning motivation and (2) on the level of the forms of learning, as the motivation of pupils for creative thinking and not simply for reproductive learning and convergent thinking. The described role is actually extremely demanding for the teacher in a professional sense. However, it is possible to implement such a role, all the more so if the teacher has more specialised knowledge from the areas of motivation and creativity; as the excerpts from the research referred to above indicate, the phenomena of motivation and creativity are interlinked in terms of content. Irrespective of the field of learning, the majority of the studies focus on the internal motivational orientation of learners (Davis, 2003), while some more contemporary studies also indicate the importance of external motivational stimuli for creative thinking.

Good and Brophy (2000) list a range of limitations in the use of purely internal motivational stimuli for school learning, emphasising in particular its situational limitation – the limitation of its application in instruction – as they believe that in instruction teachers must hold to the curricula and not only to that which is of (internal) interest to the pupils. Furthermore, the authors emphasise that time pressures in executing the curricula often pre-empt the use of active methods and forms of learning with which pupils increase their internal learning motivation. They point out that school learning is a particular type of learning, demanding of the pupils' concentration and effort - cognitive categories for which purely internal motivational stimuli are insufficient. On this basis, they conclude that it is necessary to integrate various strategies for motivating pupils, otherwise there is a danger that "… although pupils

may enjoy school activities they will not learn anything" (ibid., p. 243), that is, their achievements will not be to the extent of their abilities, both intellectual and creative. In a study in which they examined the influence of instructions that differ in terms of content (in the sense of external and internal motivational stimuli) on the creativity of pupils in the field of visual arts and language, Niu and Liu (2009) arrived at very similar findings: pupils who received more structured and more precise instructions for work demonstrated significantly more creativity in learning tasks than pupils who received looser and less structured instructions in the sense of suggesting creativity in learning.

The question that arises is therefore that of the most appropriate pedagogical approaches whose goal is to motivate the pupils for creative learning. In connection with this, Brophy (1999) critically adds, or points out, that these approaches today are significantly more developed in the area of motivation for achievements than in the area of motivation for (lifelong) learning in less productive or unproductive situations, including in various artistic fields.

How, then, can one motivate pupils for more creative learning in school? Humanistic-oriented writers (e.g., Rogers or Maslow) offered part of the answer more than fifty years ago, when in their works they emphasised the importance of a psychologically safe environment and a creative climate for the healthy personal development of pupils and for the realisation of all of their biologically given potential (self-realisation), as Davis explains (2003); in a social environment that respects and encourages creativity pupils will be made more aware of the importance of the creative and will form a positive attitude towards creativity. On this point humanistic theories converge with the socio-cultural paradigm of learning and teaching in the foreground of which is the learning community with a formed value system that with various levers of social power encourages the individual to increasingly active participation and plays a significant role in contributing to the formation of his or her motivational predisposition (Schunk and Zimmerman, 2008).

Brophy (1999) believes that learning motivation that reaches beyond the border of classical school learning on the convergent level can be encouraged by satisfying two conditions:

1) an optimal match between the learning situation and the pupil's characteristics, and
2) learning content and learning methods that are meaningful and appropriate for the pupil.

Brophy's concept of optimal match in essence follows cognitive models of development and learning, focusing on the establishment of *the zone of proximal motivational development* (Table 1).

Pupils will be motivated for learning in situations that they will either already recognise and value or will recognise as 'attractive' in the zone of proximal motivational development and that they will then, with the teacher's mediation, begin to value or positively evaluate. The author explains that motivationally effective teachers do not only teach pupils on the cognitive level (encouraging learning for understanding, problem solving, creative learning), but also on the motivational level (encouraging the formation of the value of learning, especially with regard to its applicable value in life outside school). In defining the learning content and learning methods that encourage learning motivation in pupils the author refers to the scheme of Eccles and Wigfield about three elements (1985) that form the pupil's subjective value of the learning task and represent the internal motivational orientation that encourages creative thinking.

To the first element, the value of achievement, which is originally defined as the importance of achieving success in the task for the development of the learning self-image, or for the satisfaction of the need for achievements, power or prestige, Brophy adds the experience of satisfaction due to the achieved understanding in learning or the mastery of the learning skill. To the second element, the internal value or interest as satisfaction due to the learner's own learning activity, he adds the aesthetic aspect of experience, which is very important precisely in creative learning in various artistic fields. To the third element, the applicative value of the task for the pupil's further learning development for the easier achievement of other goals connected with the learning task, the author adds the awareness of the role of learning for improving the quality of one's own life or for personal development.

According to Brophy (ibid.), the possibility of forming optimal teaching situations for encouraging the internal motivational orientation of pupils lies in teachers of various subject areas helping pupils to form the value of (creative) learning or to form motivational schemes for (creative) learning; these contain numerous cognitions with which pupils can understand and value the point of their learning.

The author emphasises three of the pedagogical approaches that have this goal:

1) modelling as social learning, when, with his or her words and physical behaviour; while teaching the teacher conveys to the pupil his or her (creative) thinking about the teaching content and describes his or her experience;
2) coaching the pupils in the process of learning with instructions, encouragement and feedback in order for the pupils to experience satisfaction due to (creative) learning, to become enthusiastic about particular learning content, to learn how to value their learning progress and (creative) achievements, etc.;
3) scaffolding as the encouragement of the development of the pupil's (creative) ability to form the values of (creative) learning and to experience satisfaction due to learning with the gradual transfer of responsibility for these processes to the pupil (e.g., by selecting teaching methods appropriate to the pupil, by forming learning goals and learning expectations, by establishing questions, learning transfer and a familiarity with the applicability of that which is learned, by evaluating one's own learning progress and achievements).

Table 1. Intersections of the zone of proximal motivational development and motivational development (after Brophy, 1999, p. 78).

ZPD = zone of proximal development	above the motivational ZPD	within the motivational ZPD	below the motivational ZPD
above the cognitive ZPD (learning is not yet possible)	The learning goals are above the pupil's current cognitive and motivational capabilities, even with the teacher's assistance creative learning is not possible (the pupil is unable to be and is not motivated).	With the teacher's assistance the pupil can develop motivation for the learning goals (they interest the pupil), but is cognitively unable to attain the creative achievement.	The pupil is motivated to achieve the learning goals but even with the teacher's assistance is cognitively unable to attain these goals as they surpass his or her current potential.
Within the cognitive ZPD (learning is possible with the teacher's mediation)	With the teacher's assistance the pupil is able to achieve the learning goals but is not yet capable of experiencing these goals from a motivational perspective (on attaining the goals the pupil does not experience satisfaction).	With the teacher's assistance the pupil is able to achieve the learning goal or creative achievement and becomes motivated for learning (learning is important and meaningful for the pupil).	The pupil is motivated for learning and with the teacher's assistance can cognitively achieve the learning goals.
below the cognitive ZPD (already learned)	The pupil has already achieved the learning goal but is not motivated for this goal and will therefore most likely not continue with learning alone (there is no challenge).	The pupil has already achieved the learning goal and with assistance is also able to develop motivation for creative achievements and to continue learning.	The pupil is productively creative – he or she cognitively and motivationally achieves the established learning goals.

5 Conclusion

The theoretical and empirical findings presented lead to the conclusion that it is possible and necessary to encourage creativity and creative thinking in school by taking into account five key findings that are derived from the analysis of the present paper:

(1) in a *creative environment* pupils will be more creative than in an environment in which creativity is not valued, not encouraged, or even not accepted;

(2) teachers who know how to recognise the *motivational orientation* of pupils in their behaviour and take this orientation into account in instruction will effectively encourage the creativity and creative thinking of pupils more so than teachers who do not take this factor into account in their pedagogical work;

(3) teachers who are familiar with and apply various pedagogical approaches with which they can, irrespective of the subject area, encourage the creativity of pupils during instruction (*modelling, coaching, scaffolding*) will more effectively contribute to the creativity of pupils than teachers who do not take this factor into account in their pedagogical work;

(4) teachers who, with regard to various learning content and learning situations and in accordance with the needs of the pupils, know how to transform or upgrade that which *is not (yet) interesting to the pupils* (because they are already familiar with it and it does not offer them further intellectual challenge, because the content is completely new and therefore arouses uncertainty, because the pupils have already had a negative experience with it) will more effectively contribute to the creativity of pupils than teachers who do not take this factor into account in their pedagogical work;

(5) teachers who have a good knowledge of the developmental-psychological and learning needs of their pupils and of their prior knowledge, and on this basis individualise pedagogical work *in the zone of proximal (motivational) development* of the pupils (Table 1) will, with the achievement of the optimal relationship between the particular characteristics of the pupils, on the one hand, and the learning content or learning situation, on the other, more effectively

contribute to the creativity of pupils than teachers who do not take this factor into account in their pedagogical work.

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GOING PUBLIC:

Pedagogical Supervisors conceptualizing their Pedagogical Practices

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1 Introduction

This paper summarizes a two-year process through which a group of teacher educators, serving as pedagogical supervisors in a leading teacher training college in Israel – The Kibbutzim College of Education Technology and Art[17] – went as they worked at conceptualizing, formulating and publishing their professional knowledge.

This process can be viewed as a local institutional initiative of a professional development activity that was aimed to empower a group of academics. Typically, although they carry most of the burden of the pedagogical preparation of student teachers on campus and at schools, this group suffers from low professional prestige and academic status when compared to their colleagues.

[17] The Kibbutzim College of Education, Technology and Art is the largest college of its kind in Israel and was founded by the Kibbutz Movement in 1939, before the establishment of the State of Israel. Currently 5,500 students are enrolled at the college for BA and MA degrees, as well as in in-service courses. The college offers education tracks in all disciplines, and has schools for the performing arts, the arts, cinematography, and various types of therapy.

This process can also be viewed from a broader perspective that touches on the epistemological and political issues that affect the status of the teaching profession: how teachers' professional knowledge is perceived, how this knowledge is generated and how teachers learn and develop professionally. We chose this broader perspective in observing, describing and analyzing the process the paper deals with.

Starting with the epistemological shift that elevated the status of practical knowledge, we describe the process whereby practical professional studies became part of higher education and the subsequent expansion and diversification of higher education programs that focus on teacher education in both the universities and colleges of education. We describe the inverse reactions to the epistemological shift that emerged in these two types of institutions – the *practitioner research movement* typical to colleges of education and the rise of the *scholarship of teaching* in the universities. In the second part of the paper we trace the process of conceptualization of innovative pedagogical practices at The Kibbutzim College of Education Technology and Art, Tel Aviv, where a group of pedagogical supervisors met in order to share, discuss, conceptualize and write about their practice. Analyses of their writing will enable us to view the process as either an instance of *practitioner research* or as an instance of turning the act of supervision into a scholarship.

2 Teachers' Professional Knowledge – The Broader Epistemological-Political Perspective

Teachers' professional knowledge and the way it is generated is tied to the way teaching is viewed as a profession. Difficulties in including it among the classical professions (Glazer, 1974) led to defining it as a mere *semi-profession* (Etzioni, 1969), and since the 1980s as a *reflective practice* (Schön, 1983, 1987, 1991). Schön described this as a move from viewing teaching as an instrumental activity, guided by a technical rationality whereby well-defined problems are solved by applying theory, preferably scientific knowledge, to regarding it as a deliberative profession where teachers are engaged in a constant process of naming and framing ill-defined professional problems. According to this view, uncertainty, uniqueness and value conflict are typically embedded in

teaching-learning situations and this requires negotiation, integration and deliberation between alternative routes of action.

This move followed an early discussion of Argyris and Schön (1974, 1978) about what they referred to as "theories of action". These authors made a distinction between the theories "in use", the tacit assumptions that govern practitioners' actions and their "espoused theories of action": the stated and often evaluated propositions used by practitioners to justify their action. Schon later elaborated this distinction into two forms of knowledge, the personal, tacit, dynamic "knowing in action" – the product of online anticipation and adjustment made by practitioners while reflecting "in the midst of action", and the more explicit, symbolic and static form referred to as "knowledge of action", usually generated when practitioners reflect following the action. Reflection was considered the main mechanism of generating both forms of knowledge:

> We reflect *in the midst of action*… during which we can still make a difference to the situation at hand – our thinking serves to reshape what we are doing…we may reflect *on action*, thinking back on what we have done in order to discover how our knowing in action may have contributed to an unexpected outcome. …While the first sort of reflection aims towards immediate correction of action, the second kind of reflection has no direct connection to the present action. It is aimed toward future action and toward the construction of formal knowledge. (Schön, 1987, p. 26)

The move from "knowing in action" to "knowledge of action" was also described by Fenstermacher and Richardson (1993a), as a move from "practitioner discourse "– the oral account of a specific, situated event in the classroom – to "researcher discourse" – the abstract propositional and theoretical account of reflection on action after the event, which usually involves justification. Fenstermacher and Richardson (1993b, p. 8) argue that to claim to know something demands that the knower will be able to supply reasons, evidence or grounds to further justify the knowledge claimed. This justification often takes steps similar to theorizing since it requires a form of practical argument that includes the description of a valued outcome of action, the theoretical rationale for action, the empirical evidence of its desired results and the fitting of the action with the situation.

Schön's ideas led into what he regarded as an "epistemological turn," …" a kind of revolution that turns on its head the problem of constructing an epistemology of practice" (1991, p. 8). The power relations between theoretical and practical knowledge (the latter of which, until then, held a lower epistemological and methodological status) shifted. As a result, this made possible further entry of practical knowledge into higher education institutions.

Global economic and social trends that occurred after the Second World War, and at an accelerated pace since the 1960s, supported this move. As the demand for skilled professionals and for practical, professional knowledge grew, academic professional knowledge became a prerequisite for better positions and earning opportunities. A call to democratize access to this type of knowledge led to the expansion of higher education as well as to its diversification from monolithic research-oriented institutions to less selective and more inclusive institutions, which provided academic professional practical education to less privileged population groups. However, the growing understanding that professional knowledge actually integrates the old dichotomies of theory and practice, public and personal, declarative and procedural, analytic and intuitive, led the two tiers of higher education, the universities and the colleges, to come closer and converge in their professional academic programs.

We will now look at this convergence while focusing on changes related to the education of teachers in higher education institutions: the less selective colleges of education and the research universities' schools of education. Here opposite processes led to convergence of the respective teacher education programs.

In colleges of education, from the 1970s, the move was toward academization. Institutions that had until then been called "seminars" were transformed into academic colleges offering B.Ed. and M.Ed. degrees, and even opting for D.Ed. degrees. This required, among other things, the enhancement of college teachers' academic activity that grew into a type of "practitioner research". In the universities, at the same time, awareness of their teacher preparation programs' relatively poor attention to practical aspects of teaching and their limited contact with schools resulted in offering more practically-oriented courses and in a proliferation of partnership programs between universities and colleges of education or between universities and schools; these relations were

more or less symmetrical, with the universities sometimes patronizing the other partners.

Another move the universities went through was redefining the meaning of academic scholarship to include beyond research and publication, a commitment to what was defined as a "scholarship of teaching".

These processes also occurred in the Israeli context (Ayalon & Yogev, 2005; Guri-Rosenblit, 1993; Menachem, Tamir & Shavit, 2008; Yogev, 2008). A major expansion of higher education started in the 1990s. Since then, the number of students enrolled in higher education institutions has almost tripled from about 75,000 to about 232,000 in 2009. Diversification is evident from the fact that while in 1990 all students studied in research-type institutions, in 2008/9 about half of the students were enrolled in less selective private and public regional academic colleges (85,000) and in academic colleges of education (26,000) where most teacher education is carried out (CBS, 2009).

There are marked differences between schools of education at the universities and colleges of education in terms of the structure of their programs: concurrent programs at the colleges in which disciplinary studies and pedagogical studies are integrated versus consecutive programs where the pedagogical studies follow disciplinary graduate studies; curricular emphasis (practical-pedagogical in colleges vs. theoretical-disciplinary in universities); admission requirements (higher in universities); staff employment requirement for doctoral degrees (strict at the university), and academic and administrative autonomy (greater in universities) (Ariav, 2008; Avdor, 2001; Dror, 1999; Zuzovsky & Donitza-Schmidt, 2004).

The main differences stem from the fact that while universities are supervised by the Commission of Higher Education and have a substantial degree of autonomy in academic and administrative affairs, colleges of education have much less autonomy as they are subordinated to two regulators: the Ministry of Education, with regard to curriculum, budget, student quotas, teachers' salary and working conditions – and the Commission of Higher Education in matters of academic standard and accreditation. Other differences are related to staff promotion. While in the university, professional advancement depends on research productivity and less on excellence in teaching, at the colleges of

education, research productivity weighs in significantly only for top ranking employees, while teaching and fulfilling other duties such as leading projects, participating in committees, count strongly in the lower ranks. As a result teachers in colleges of education invest less in research, postponing this activity to later years in their careers. Given the heavy teaching load of those who work in the colleges compared to the trainers in universities, their low yield of scholarly research publications is not really surprising.

In Israel, however, at present there is underway a consistent move toward unification of teacher education programs. Colleges of education, since 1979, have been involved in a process of academization: initially they started offering programs toward the B.Ed. degree and later on, from 2000, for the M.Ed. (Kfir, Ariav, Fejcin, & Liebman, 1997). These programs required placing more emphasis on disciplinary studies, raising both the student entry requirements and hiring demands for teacher educators.

At the universities, other processes occurred. As teacher education at the Israeli universities is problematic, partly due to the low status of educational research compared to other fields of study at the university, and also because of the universities' inferiority in the practical-professional aspects of preparation, university schools of education in Israel initiated different forms of partnership programs with colleges of education (Guri-Rosenblit, 1999) or with schools, in the form of professional development schools, where university scholars become involved at schools and school teachers are recruited to work at the university (Dror, 1999; Hoz, 1999). There has also been a call to link scholarly research in education to study teaching practice as part of the supervision of Ph.D. thesis (Nevo, 1999). The result of these opposite processes led to a change in higher education policies that supports the convergence of the two types of teacher education institutions. Two examples of recent policy direction illustrate this change: The Commission of Higher Education's recent approval, in 2005, of a common model of teacher education for both universities and colleges of education and the latest tendency, not yet realized, of placing academic teacher education institutions, like the universities, under the supervision of the Commission of Higher Education.

Summing up these processes, two trends that resulted in the convergence of teacher education in higher education institutions can be

identified: the strengthening of practitioner research, and the expansion of academic functions of scholars to include the scholarship of teaching. A short description of these two trends follows below.

2.1 Strengthening Practitioner Research

The teachers' research movement has been growing ever since the 1970s, taking different forms. Amongst these, action research and participatory action research are very popular (Anderson & Herr, 1999; Carr & Kemmis, 1986; Herr & Anderson, 2005; Noffke, 1997, Noffke & Somekh (in press), Zeichner & Noffke, 2001), as well as teacher self-study (Bullough & Pinnegar, 2001, Loughran et al., 2004).

In all variants of practitioner research, the researchers' professional context is the site for inquiry and the problems and issues within professional practice are the focus of investigation. As a result the boundaries between research and practice are often blurred.

Cochran-Smith and Lytle (2004) used the phrase "working the dialectic" to describe these blurred boundaries that characterize practitioner research:

> …reciprocal, recursive, and symbiotic relationships of research and practice, analysis and action, inquiry and experience, theorizing and doing, and being researchers and practitioners as well as the dialectic of generating local knowledge of practice while making that knowledge accessible and usable in other contexts and thus helping to transform it into public knowledge. (p. 635)

This dialectic leads the authors to view all these variants of practitioner research as expressions of what they call "inquiry as a stance". In choosing this metaphor they pay attention to both its orientational and positional meanings.

> …to carry illusions to the physical placing of the body as well as to the intellectual activities and perspective over time. In this sense, the metaphor is intended to capture the way we stand, the ways we see and the lenses we see through. (Cochran-Smith & Lytle, 1999, p. 288-289).

In a later publication they expand the meaning of this metaphor to include in it a critical and political dimension.

> A way of knowing and being in the world of educational practice that carries across educational contexts and various points in one's professional career and that links individuals to larger groups and social movements intended to challenge the inequities perpetuated by the educational status quo (Cochran-Smith & Lytle, 2009, p. VIII).

2.2 The Scholarship of Teaching

This term was coined in 1990 by Ernest Boyer, the then president of the Carnegie Foundation for the Advancement of Teaching in the USA as part of a report that challenged long held notions of academic work at the universities. The basis of his argument was the dichotomy between theory and practice which he rejected.

> Scholars are academics who conduct research, publish and then perhaps convey their knowledge to students or apply what they have learned…But knowledge is not necessarily developed in such a linear manner. The arrow of causality can, and frequently does, point in both directions. Theory surely leads to practice. But practice also leads to theory and teaching at its best, shapes both research and practice. (Boyer, 1990, p. 16)

Boyer then suggested adding new meanings of scholarship to the accepted notion of "scholarship as discovery":

- as integration – making connections between isolated facts across the disciplines, placing specialties in a larger context;
- as application – putting knowledge into use, as new intellectual understanding arising from the very act of application: here theory and practice vitally interact, with one renewing the other, and
- as scholarship of teaching – the dynamic endeavor that builds bridges between teacher understanding and student learning.

Lee Shulman, who stepped into Boyer's position at the Carnegie Foundation, further refined the meaning of scholarship when he distinguished it from merely excellent teaching, adding the following three central features: being public (i.e., property of the community),

being open to critique and evaluation and taking a form that others can build on. In Shulman's words:

> A scholarship of teaching will entail a public account of some or all of the full act of teaching – vision, design, enactment, outcomes, and analysis – in a manner susceptible to critical review by the teacher's professional peers and amenable to productive employment in future work by members of that same community. (Shulman, in The Course Portfolio, 1998, p. 6.)

He added that scholarship of teaching requires a kind of "going meta", i.e., investigating not only to improve teachers' own classroom, but to advance practice as such, and not only to find solutions to urgent problems in practice, but also to discover problems worth pursuing through ongoing investigation: "It is the mechanism through which the professions of teaching itself advances" (Hatchings & Shulman, 1999, p. 11).

3 The Local Perspective – Pedagogical Supervisors Going Public

We will refer to the two movements that we described above - *practitioner research* and *scholarship of teaching* - to observe and interpret processes that occurred in a large, leading college of education in Israel. Like other colleges of education since the late 1980s, this college went through a process of academization and was accredited to award B.Ed. degrees, and, since 2000, M.Ed. degrees. The number of full-time teaching positions in the college amounts to 300; a third of these positions are held by pedagogical supervisors. Most of them are women in their 40s to 50s. Excellent, experienced teachers in their former careers, they continued their learning toward advanced second and third degrees.

It is the job of this group of faculty members to prepare and supervise students in their field of experience and they are responsible for making the connection between the theoretical-pedagogical studies and practical work. The main activities they carry out are related to teaching, coordinating projects and developing learning material. Only a few of them are engaged in research and their yield of academic publications is

low. These are part of the reason for their low professional status compared to others in the college who teach disciplinary or educational foundation courses.

In an attempt to improve this state of affairs, the college decided to initiate an activity aimed to empower this group of teachers. A leading group of pedagogical supervisors were invited to participate in a series of professional meetings conducted by outside experts from a professional supervisory agency to discuss their practice, conceptualize it and write a paper to be published as an academic publication. The twenty selected pedagogical supervisors met throughout the year. Each presented his/her ideas, discussed it with other members of the group and started a cyclical process of writing, sharing and revising. Half of the resulting papers were of publishable quality. At this point, two additional figures, the editors of the publication to which these papers were submitted, became involved with the writing process. It took almost one additional year until satisfactory results were attained. While the role of the group supervisor was mostly to help in the conceptualization stage, a role which could also be described as "midwife", the complementary role of the editors, who were involved in producing the end product – the published paper - was that of a private coach, helping the participants in formulating and writing their papers.

4 The Yield of the Writing Group

The papers that actually came out at the end of the process dealt with pedagogical ideologies as well as with practices which their authors considered to be highly representative of their work; they also matched and reflected the grand pedagogical visions of the college, which aims to prepare professional educators with a commitment to social and political change.

The papers yielded by the workshop fit into two broad categories: papers with a focus on a unique ideology or a pedagogical approach toward teaching and educating teachers – which we hence called *programmatic papers*, and others which focused on describing and justifying a specific practice – *called practice-oriented papers*.

In the following section we present a short description of each of the papers. An attempt to characterize each paper in terms of some distinctive features will follow this presentation.

4.1 The Ideological-Programmatic Papers

Democratic 'Parenteaching' – this unique term aimed to convey a view of teaching as a parental, nurturing activity rather than as mere knowledge transmission. Anchored in philosophical ideas from Socrates to Dewey, this paper attempts to justify a dialogical type of supervision aimed to strengthen powerful capacities of the individual student teacher, on lines similar to an advocated teaching approach in the regular classroom. This paper is written with much emotion and powerful conviction.

Educating Educators through Academic-Service Learning – This supervision model is rooted in a perception of teaching as a transformative activity that leads toward social change. It claims that student teachers learn to teach while they are engaged in providing educational and social services to children in weakened communities. The supervision practices employ writing reflective journals as well as reading theoretical and research-oriented sources.

The paper presents narratives collected from the reflective journals of the participating student teachers. This illustrates how student teachers construct their understanding of socially weak populations and develop social and cultural awareness. This evidence is used to confirm and justify the presented pedagogical approach. The paper ends with raising some critical questions regarding the long-term and sustainable effect of this pedagogical approach.

Building Social Awareness Among Early Childhood Educators and *Power Relationships as a Theme in Pedagogical Supervision:*
These two papers emerge from critical feminist pedagogical approaches that are aimed at uncovering existing social inequality and discriminatory mechanisms rooted in the educational system. This ideological perspective is expressed in the supervision practice of both authors.

The author of the first paper reflects on the problematic aspects of the "empowerment" discourse usually employed in the education of female

early childhood teachers and offers another discourse marked by "sharing power" to substitute the former. This discourse is translated into a practice of granting the student teachers the freedom to decide for themselves about the nature of their curriculum and practical experiences. Somewhat contradictory to this idea, the dominant voice in this paper is the voice of the writer – the supervisor - who weaves together theoretical arguments and a description of practice, trying to persuade the reader of her own beliefs rather than allowing the voice of the student teachers to be heard. The author is aware of the tension between her critical stance and the fact that she operates within a traditional institute.

The author of the second paper describes an opportunity to witness unequal societal relations by analyzing the power relations within a heterogeneous supervision group she regards as a meeting place for cultures and identities. She, too, advocates shared creation of the pedagogical curriculum by the student teachers and their supervisors and shared management of the program by all supervisors working in this program as a way to build solidarity and make power relations in the supervision classroom more symmetrical.

The writing in this paper is strongly ideological and persuasive. The author relies relatively less on theoretical sources. She takes a critical attitude toward her own approach, identifying tension between her drive for equality and working within an unequal system.

She also points to a frequent confusion arising when students are given the power to decide for themselves on issues of curriculum and their subsequent interpretation of this freedom. She claims that giving up 'authoritativeness' should not be confused with giving up 'authority'. She is aware that the ethos of sharing in supervision settings is risky.

4.2 The other papers were more practice-oriented. Following are some examples:

The Dynamics in the Supervision Group

This paper highlights the similarities between group dynamics processes in the supervision group and in other groups: the teachers peer group and students in their classrooms. The dynamics in the groups are tied to developmental stages through which the group is going and to the changing relations between the supervisor and the group members. Following a theoretical elaboration, the author analyzes an encounter with a student which led her to offer an experiential and creative role-play activity to overcome anxiety situations in the supervision group – a typical situation in group dynamics.

Most of the intellectual effort in writing this paper is related to synthesizing theories and constructing a conceptual rationale for the suggested practice. In this sense, this is not a typical research paper, but rather a conceptual essay on practice.

P-D-K (Professional-Development Kindergartens)

This paper describes an attempt to implement the idea of professional development schools in a kindergarten. Dissatisfaction with the traditional training of early childhood student teachers, and exposure to the theory and practice of professional development schools, guided this author in her role as the head of the early childhood department in the college, to initiate partnership relations with kindergartens in a nearby town. The paper provides a lengthy literary review on the professional development-school movement and a detailed description of all organizational arrangements and pedagogical activities that went into realizing the notion of professional-kindergarten development. The author cites the student teachers and their mentors and presents the results of an evaluation study carried out by the research unit in the college to confirm the success of this initiative.

Reflection? Reflection, Reflection!

In this paper the author tries to understand why student teachers have negative reactions toward *reflection* while she perceives it as a powerful tool for learning and professional development.

Starting with a literature review on types of reflection, the author soon moves to present and analyze her own and her students' reflections on an activity that took place in her supervision class. Using examples to highlight the advantages of reflection, she moves to offer a practical guide for fostering reflective writing. She identifies several steps in this practice: free associative writing, identifying problems, analysis, extension and final evaluation, which then leads to identifying further problems and further need for reflection. In this sense, reflection is endless. While most of the paper takes a very personal viewpoint, when it offers a practice, the writing becomes prescriptive and less personal.

A Reading-Journey Journal

The author starts by defining and explaining the meaning of "a reading-journey journal" – a journal that combines reading and responding to it in writing. When student teachers read children's books they get to know children's literature and when they reflect on what they read, they discover their own pedagogical values and professional identities. A collection of reading-journey journals, enabled the author to classify them according to several criteria: content, self-awareness of the writers, personal voice, the dialogic nature of the writing, the reflective narrative.

The second part of the paper is a detailed account of how writing the reading-journey journal affected both the student teachers and their supervisor. This led the author to discuss some problematic aspects of the technique – the resistance vs. the challenge this activity arouses, the fact that publication can both empower the writer, but also may inhibit the writing. The paper ends by recommending that teacher training programs provide more opportunities for reflective-narrative responses to reading; provide the scaffolding necessary for writing and for allowing the supervisor to approach the whole process as an inquiry.

Using Personal Stories in Supervision Meetings

If we view teaching as interplay between the personal and the professional, personal stories can offer a source for professional development. The author uses the example of a personal story to demonstrate the practical-professional knowledge that can be gained from it. The author also discusses the tension between the therapeutic and the professional functions of storytelling. Here too, the paper ends

with offering models to integrate storytelling and analysis in the supervision practice.

5 Discussion

All papers exhibited, in different proportions, a mixture of ideological-programmatic writing, in which the writers exposed the values and beliefs guiding their work, and a descriptive account of their actual practices in the attempt to achieve these goals. The papers exhibited interplay between personal reflective writing and theoretical writing, and the tone of the writing varied from neutral descriptions and justifications to impassioned, personal advocacy.

The papers also differed in the amount of evidence they provided in support of the advocated ideology and praxis. Many ended with a critical-reflective recapitulation and pointed out uncertainties, dilemmas and unsolved questions still awaiting inquiry, as is usual in academic writing.

When reflecting on their own writing, some authors highlighted the role of sharing their ideas with the other members of the group.

In an attempt to delineate commonalities and differences between the papers, we paid attention to several features that are commonly used to define teachers' ways of writing when conceptualizing their practical knowledge, as well as to other features, that emerged from their actual writing in the present activity. These are:

- The type of the writing – programmatic-ideological vs. descriptive - practical.
- The text focuses on public theoretical knowledge vs. private, reflective knowledge.
- The tone of the writing – neutral, evidence-based or emotional, based on beliefs and values.
- The amount of linking between the private experience issue and a general educational context.
- The degree to which the text aims to confirm or to justify a practice or a world view.
- Reflections that focus on collaboration with other members of the group.

– Self critique, raising questions concerning the presented pedagogical approach or practice.

After reading the papers several times, we assessed in an impressionistic, holistic way, the degree to which each of the above characteristics was present in each paper. We indicated this on a scale ranging from a low (+) intensity, via medium (++), to high (+++). The following table summarizes this analysis.

Table 1. Characteristics of the Papers.

	Type of Writing		Emphasis on Knowledge		Tone of Writing	
	Programmatic-Ideological	Prescriptive-Practical	Public Theoretical	Private Reflective	Neutral Evidence-Based	Emotional Belief-Based
Democratic 'parenteaching'	+++	+	+++	+		+++
Educating educators through academic service learning	+++	++	+++		++	
Building social awareness among early childhood educators	+++	+	+++	+	++	++
Power relationship in pedagogical supervision	+++	+	++	+		++
Group dynamics in supervision class	++	++	++	++		
P-D-K (Professional Development Kindergarten	+++	+++	++	+	++	
Reflection? Reflection, Reflection!	+	+++	+	+++	+	+++
A reading journey-journal	+	+++	+	+++	+	
Using personal stories in supervision	+	+++	++	+++	++	

Table 1. Continue

	Linking Private Issue to General Context	Presence of Evidence to Justify Approach	Collaboration	Self-Critique
Democratic 'parenteaching'	++	–	+	–
Educating educators through academic service learning	++	+++	+++	+
Building social awareness among early childhood educators	++	+	++	+
Power relationship in pedagogical supervision	++	++		+
Group dynamics in supervision class	++	+++		
P-D-K (Professional Development Kindergarten	+	+++	+++	
Reflection? Reflection, Reflection!	++	+++	++	+
A reading journey-journal	++	+++	++	
Using personal stories in supervision	++	+++	+++	

The table highlights some features that distinguish between the ideological programmatic papers (1-4) and the practice-oriented ones (5-9). Although the differences are not clear-cut, it is evident that *all four programmatic papers* offer only minor suggestions for practice. In most of them, theory is the basis for justification of the practice and not empirical evidence. The presence of reflective writing is minimal and the tone of writing is self-convinced, emotional and belief-based. The practice-oriented papers, on the other hand, demonstrate more reflective

writing and contain both prescriptions and detailed descriptions of the advocated practice. These papers provide narrative evidence that confirms and justifies the advocated practice. In all papers, both ideological and practical, there is a tendency to move from the private experience to a more general one.

6 Summing up

In summing up this long process, it became clear that the activity did not resemble a systematic process of inquiry, even if some of the papers presented contained elements of inquiry: a problem was posed, data in the form of narrative accounts were presented, and conclusions were drawn. However, it was evident that the authors were less research-oriented in presenting their ideas and more interested in presenting and summing up chapters of their professional life.

Although the papers were probably produced following an inquiry stage, they should be viewed as an instance of the "scholarship of supervision", namely, giving a public, written account of an act of supervision. The central features of such scholarship are: "going public", "opening up to professional peer critique" and going "meta", that is to say: rather than only looking for a solution to a specific, problematic situation, the participants, here, were involved in an attempt to enrich the general professional knowledge.

The scholarship of supervision was reflected in the emphasis given to the process of writing. Between the effort they put in the conceptualizing endeavor and the writing endeavor, the writing experience became the most important one.

One of the members of the group aptly describes this experience by means of the metaphor of distillation:

"A process of distillation that turns the original text into a paper…All actions that took place while turning the text from a private one into a public one…Actions that touched upon emotional, practical and cognitive aspects".

"…This process started with eliminating redundant passages from the text. Next, there was a need for expansion, abbreviation, reformulation,

and structural change in order to generate a clearer and more understandable text".

At some point, moreover, the critical and sensitive reading of other members of the group was also required. Their responses charged the authors with renewed motivation to "open" the already "closed" text and engage in another cycle of refinement or distillation.

Other things the participants wrote, regarding writing as an act of empowerment and professionalization, can also be used to sum up the workshop activity.

Empowerment

"Writing gives one a sense of more space and more power…When you write things down they become more real… Once I write things down I can no longer ignore what I have recognized in myself in the way I would when not writing them down".

"…Reflecting and writing on my supervision enabled me to take responsibility for both the good and the problematic aspects of my practice. This opens a safe space for me and for my students to process both powerful and weak parts of our being".

Professionalization

"Reflecting and questioning the supervision activity as was done in the group, is a way to professionalize the practitioner, the system s/he belongs to and the profession itself".

At the level of the individual practitioner the activity offers an opportunity for a thorough look at the work of supervision, allowing both theoretical and practical improvement in a way that contributes to better understanding and improvement.

At the system level, the activity marks the boundaries of the supervisor's role, delineates the topics, contents, pedagogical principles and values underlying supervision, and this in turn provides a basis for policy-decisions.

At the professional-political level this activity contributes to the growth of professional knowledge; sharpens dilemmas and exposes alternative ways to manage them. It also expands our understanding in matters of

teacher education and situates supervision more appropriately in terms of importance.

Since we collected participants' papers (indeed, they are now in the process of publication) we can also conceive of the activity as an example of shifting from the *act of supervision* as such to the *scholarship of supervision*. This process enriched all the partners involved. The members of the writing workshop gained intellectual self efficacy. The college that provided this opportunity improved the academic status of its pedagogical supervisors, and the supervisors of the group, including us, the editors of the publication, gained insight into the process of elevating the act of supervision into a scholarship.

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THE FACTORS OF ENCOURAGING TEACHER INNOVATION FROM THE PERSPECTIVE OF TEACHERS AND HEADMASTERS

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ABSTRACT

In today's rapidly changing world the teacher's role is becoming increasingly demanding and the expectations of the teacher ever higher. The capacity for constant diagnosis and innovating with regard to one's own pedagogical practice has become one the teacher's fundamental competences. All of this demands unceasing learning and professional development, both of individual teachers and of the entire school, presenting a new challenge for the education of teachers.

In the paper Slovenian researchers present the results of a research into the question of which factors, from the perspective of Slovenian teachers and headmasters, could contribute to an increase in innovative teaching. The study revealed the teachers' and headmasters' self-assessments of their competence in planning, implementing and evaluating pedagogical innovations, the teachers' and headmasters' attitudes towards innovation and changing their teaching practice, and how this is related to their job satisfaction.

KEY WORDS: Innovation work, Attitudes towards innovating, The teacher's experience with research, Conceptions of research, Teachers' competence for innovation, Headmasters

1 Introduction

Development of science and technology and economic and social changes have a significant impact on educational practice in terms of aims, methods, demands and conditions of teachers' work. Jorgensen (2006) poses the question of why innovation in education is a must. There are at least three reasons: a) the number of new research insights into teaching and learning (e.g. streaming approaches and individualization of teaching, theory of multiple intelligences), b) the ever more complex educational aims and more diverse and demanding learner groups, and c) the pace with which information becomes obsolete. Hargreaves et al. (1998) point out many challenges that today's schools and teachers are facing:

- "new and often tightly defined curriculum targets, standards or outcomes that emphasizes various kinds of higher order thinking
- more systematic and pervasive forms of standardized testing alongside more "authentic" portfolio and performance-based kinds of classroom assessment
- innovative teaching strategies such as cooperative learning, manipulative mathematics and reading recovery
- the impact and rapid spread of new technologies, especially computers, on classroom practice
- greater attention to "constructivist"-inspired forms of teaching and learning, that seek to develop teaching-for-understanding, help children grasp the deep structures of their subjects, and take into account their prior knowledge and beliefs
- more insistence on "robust" kinds of educational accountability through such strategies as rigorous external inspection, and measurements of school performance which are in turn linked to levels of funding, or are published in school-by-school league tables of results
- increased attentiveness to parents' rights, wishes, choices of school and involvement in school governance
- an ever-increasing influence and imposition of market principles on education, where schools must compete for clients, be conscious of how they perform compared to their competitors, and manage their image with diligence and care

- more involvement of business in education through sponsorships, partnerships, curriculum innovations and the intrusion of its corporate concepts into the overall language of educational reform
- various measures to improve the status, standing and quality of teachers from defining professional standards or competences through to compulsory re-certification of teachers on a periodic basis
- numerous efforts at local and regional levels to bring about whole-school improvement, to restructure schools and attempt to change the entire way they operate"

The authors (ibid) stress that what is significant and daunting for educators today is not the existence of educational changes as such, but the distinctive and sometimes disturbing forms it has come to take at the turn of the century.

One of the fundamental conditions for significant changes of educational practice is the teacher's competence for innovating and research. The demand for the constant changing of one's own pedagogical practice is not new. The German educator and teacher trainer Diesterweg ironically stated as early as in 1835 that expectations concerning teacher's work are unrealistically high (Buchberger, 2001, p.51). As early as in the 1960s, experts of the 'Roman Club' (according to Marentič-Požarnik, 2000, p. 282) emphasised the importance of innovative learning with two components: anticipatory, which is based on anticipating the future (emphasising creativity, long-term effects, responsibility, etc.), and participatory, which emphasises the significance of the democratic participation of everyone who is affected by the decisions about the future (emphasising holistic thinking, identifying alternative solutions of a particular problem, etc.). Thus in 1971, the German Council for Education placed the teacher's capacity and preparedness for innovation amongst the five most important tasks of the teacher. Other countries followed suit (e.g. Scandinavian countries and Great Britain), but the extent to which they managed to train teachers for successful innovation has not yet been established (Buchberger, 2001). In its Memorandum on Lifelong Learning, the European Commission also emphasises the importance of innovation in teaching and learning (Concluding Report No. 3) and establishes the goal of the development of efficient methods

of learning and teaching, as well as the development of the conditions for constant learning throughout life for all social roles in diverse content and forms (Commission of the European Communities, 2000).

These orientations rest on the assumption that existing practice is upgraded. The 8th project of the Council of Europe – Innovation in Primary School defines innovation as change of the general character and specific modifications of the existing educational practice. Innovation, thus, does not only mean new educational policies but also their implementation at all levels of the educational system from the Ministry of Education to the classroom.

Instance (2008) asks the question of which competences today's children need to develop, and stresses in his answer critical thinking and problem-solving skills, creativity, communication and teamwork skills. The premises of the curricular reform in the Republic of Slovenia, too, reflect a broader conception of knowledge. The quality of knowledge is no longer measured only by the quantity of facts and generalizations learned, but by its durability and usefulness for solving new problems, understanding oneself, other people and the environment, and the ability to acquire new knowledge (Izhodišča kurikularne prenove 1997).

From the documents mentioned above it is evident that for quality execution of the educational process it is essential for teachers to realise the significance of innovating and to be capable of implementing innovations in their own pedagogical practice. Furthermore, educational processes must be designed in such a way that they also develop creativity and innovation in pupils.

In the present article we define didactic innovation as *"the process of forming theoretically considered and practically founded changes in instruction that are a result of conscious, planned and creative work of teachers and will in the process of execution lead to an improvement of existing school practice on the levels of the teacher's didactic skill and his or her conceptions, attitudes and thinking, the school atmosphere and the teacher's broader understanding of his or her own professional development."* (Valenčič-Zuljan, Kalin 2007). We should emphasise that in such a conception of innovation and innovating stress is not only on the end result but also on the process of

innovation in the broader school and social context in which innovating takes place.

When we consider the teacher's innovating of his or her own pedagogical practice, various questions arise. To what extent are teachers prepared for changes in their own pedagogical practice? What encourages them in this endeavour in what hinders them? What is the role of the staffroom atmosphere, colleagues and the headmaster in innovation? How does one design a programme of teacher education that teachers will be capable and prepared to change their own educational practice throughout their entire professional lives?

In forming teachers' attitudes towards innovating their own pedagogical practice, as well as in specific training for innovating, the education of teachers plays a very important role, in terms of both content and methods. Of particular importance in this context is the teacher's capacity to undertake research that enables systematic gathering of data about the implemented innovation, with the aim of providing a value judgment regarding the innovation and/or providing a basis for improvement. A series of research projects (e.g., Fullan, 1982, 1998, Valenčič Zuljan, 1993 and 1996) confirm that successful innovating cannot be directed from outside, nor from above, but that successful innovations are primarily those derived directly from practice and implemented and evaluated by practitioners, often with the help of other experts.

2 The Research

2.1 Purpose and Objectives of the Study

The paper aims to answer the following research questions:

1. How do teachers and headmasters view their own competence in implementing and evaluating pedagogical innovations?
2. What are the teachers' and headmasters' attitudes towards innovating and changing their teaching practice, and how are these attitudes related to the degree of their job satisfaction?

3. Which factors, according to teachers and headmasters, would most contribute to an increase of teacher innovativeness?

2.2 Methodology

The research was designed as a descriptive and causal non-experimental educational study (see Sagadin, 1993).

2.3 Sample

The questionnaires were completed by 1042 teachers and 59 headmasters. 82.6% of teachers were women and 17.4% were men. The average age of the teachers surveyed was 42.12 years (with a standard deviation of 9.06 years), and they had an average of 18.14 years of work experience (standard deviation of 10.15 years). Two thirds of the teachers (68.3 %) work in primary schools, 16.9 % in grammar schools, and 14.8 % in vocational secondary schools.

33.9% of headmasters were women and 66.1% were men. The average age of the headmasters surveyed was 50.29 years (with a standard deviation of 6.52 years), and they had an average of 27.22 years of work experience (standard deviation of 6.83 years). On average they have 9.5 years of work experience as a headmaster. Two thirds of the headmasters (66.1 %) work in primary schools, 22.1 % in grammar schools and 11.9 % in vocational secondary schools.

2.4 Data collection

Data collecting was carried out in May 2010. We prepared a questionnaire composed of four evaluation scales, semantic differential and a set of questions with which we try to collect certain personal data about our teachers and headmasters (sex, age, years of employment, level and orientation of education, faculty, professional title, type of institution where they are employed).

2.5 Data processing

The data from the questionnaires were treated on the level of descriptive and inferential statistics. In so doing we used the frequency distribution (f, f %) of attributive variables, basic descriptive statistics of numerical variables (measures of the mean, measures of distribution), the Kullback

2I test for hypothesis independence, the Levene test of the homogeneity of variances (F-test), and the t-test. The data are shown in tabular form.

3 Results

3.1 Teachers' innovation competence

The first research question aimed to reveal teachers' and headmasters' self-assessments of their competence in planning, implementing and evaluating pedagogical innovations.

It is encouraging that only 6,6 % of the surveyed teachers and 3,4 % of the headmasters consider themselves completely untrained for designing teaching innovations. Half of the headmasters (50,0 %) and the largest share of teachers (47,4 %) consider themselves to have average competence in planning educational innovations. Almost a half of the teachers (46,0 %) and headmasters (46,6 %) consider themselves to be competent or very competent in designing pedagogical innovations. The answers of the teachers in headmasters did not differ statistically significantly (2I = 1,675; g = 4; P = 0,795).

Statistically insignificant differences between teachers and headmasters also showed in their self-assessments of implementation competence (2I = 2,417; g = 4; P = 0,660). Half of the headmasters (50,0 %) and almost a half of the teachers (49,1 %) consider themselves to be competent or very competent in implementing pedagogical innovation. Only slightly smaller shares of both respondent groups (45,3 % of the teachers, 46,6 % of the headmasters) stated they were averagely competent in this area. The shares of teachers (5,6 %) and headmasters (3,4 %) who consider themselves untrained or entirely untrained for implementing pedagogical innovation are small.

Somewhat bigger differences between teachers and headmasters, which are still statistically insignificant (2I = 8,216; g = 4; P = 0,084) showed in the respondents' assessments of their competence in evaluating the effectiveness of pedagogical innovation. While half of the headmasters (50,0 %) see themselves as well to very well trained to evaluate the effectiveness of pedagogical innovation, only a third of the teachers

chose this response (34,3 %). Most of the teachers (53,3 %) and 44,8 % of the headmasters consider their competence in the area of evaluating innovations to be average. 12,4 % of the teachers and 5,2 % of the headmasters stated they were untrained or entirely untrained in this area.

For effective educational practice it is crucial that teachers are trained to design, implement and evaluate pedagogical innovation. The research results presented show that both teachers and headmasters see themselves as quite competent in designing and implementing innovations, but teachers are less confident about evaluating their effectiveness. Evaluation, however, is a key stage since is provides feedback on the effectiveness of an innovation that enables us to immediately improve the innovation if needed. Even though evaluation is the last stage in the process, it should not be considered the end of it. Evaluation is the step at which we gain the data needed to plan further action, and this is all the more efficient if it takes the form of self-evaluation (Plestenjak and Cencič 1999).

In order for teachers to commit to research it is vital to prepare them for this during their undergraduate studies; they have to become aware early on that research of educational practice is one of the instruments for establishing and ensuring the quality of this practice, that they recognise research as an important factor of the professional conduct of teachers, and that they be fully qualified for research. There is ample evidence that teacher research can be a powerful factor in the lives of the teacher-researchers: teacher researchers report learning more about their students, about their schools, and about themselves; they use this knowledge to change their practice, to feel more professional, to engage ˝authentically˝ with the profession of teaching in a new way (for more on this see Berger, Boles & Troen, 2005).

3.2 Attitudes of teachers towards innovating and changing their own teaching practice

A very important factor in the teacher's decision to become involved in research and innovation is his or her attitude towards innovating. We were thus interested in the extent to which teachers and headmasters favour the idea of innovating and changing their own teaching practice.

	Do not favour at all		Do not favour		Favour to some extent		Favour		Favour completely		total	
	f	f %	f	f %	f	f %	f	f %	f	f %	f	f %
Teachers	5	0,5	27	2,6	263	25,6	481	46,8	252	24,5	1028	100,0
Headmasters	0	0,0	0	0,0	6	10,3	27	46,6	25	43,1	58	100,0
Total	5	0,5	27	2,5	269	24,8	508	46,8	277	25,5	1086	100,0

The answers of the teachers and headmasters about their attitudes towards innovating and changing their own teaching practice were significantly different (2I = 16,264; g = 4; P = 0,003). While almost a half of the headmasters (43,1 %) stated they were very much in favour of innovating and changing their own teaching practice, only a fourth of the teachers felt that way (24,5 %). Equal shares of teachers (46,8 %) and headmasters (46,6 %) are in favour, a quarter of the teachers (25,6 %) and a tenth of the headmasters (10,3 %) in favour to some extent. 3,1 % of the teachers surveyed responded that they are not in favour or not at all in favour of innovating and changing their own teaching practice (none of the headmasters chose this response).

One of the aims of the survey was to establish possible correlations between the respondents' attitudes towards innovating and changing their own teaching practice and the degree of their job satisfaction.

	Do not favour at all		Favour to some extent		Favour		Favour completely		total	
	f	f %	f	f %	f	f %	f	f %	f	f %
Very satisfied	8	3,7	29	13,4	93	42,9	87	40,1	217	100,0
satisfied	12	2,0	154	25,2	312	51,1	133	21,8	611	100,0
Somewhat satisfied	11	5,1	69	31,8	87	40,1	50	23,0	217	100,0
dissatisfied	1	4,0	8	32,0	11	44,0	5	20,0	25	100,0
Total	32	3,0	260	24,3	503	47,0	275	25,7	1070	100,0

The teachers and headmasters assessed their job satisfaction using a five-level scale. Because very few teachers and headmasters (2,3%) claimed to be dissatisfied or entirely dissatisfied with their profession, we joined these two levels in further data processing into one category. Over a half of the surveyed educators (57,1 %) are satisfied with their profession, a fifth (20,3 %) are very satisfied and the same share reported to be somewhat satisfied.

There are, however, statistically significant differences in attitudes towards innovating and changing their own teaching practice between the groups of respondents with varying degrees of job satisfaction (2I = 48,585; g = 9; P = 0,000). While two fifths of the very satisfied respondents (40,1 %) are very much in favour of innovating and changing their own teaching practice, this attitude was reported by a smaller share of those who are satisfied (21,8 %), somewhat satisfied (23,0 %) or dissatisfied (20,0 %). A somewhat favourable attitude towards innovating and changing their own teaching practice was reported by the smallest share of educators with a high degree of job satisfaction (13,4 %), a quarter of the satisfied respondents (25,2 %) and almost a third of the somewhat satisfied (31,8 %) and dissatisfied (32,0 %) teachers. The mid-point response (in favour of innovative teaching) was chosen by the most respondents regardless of their degree of job satisfaction: two fifths of the respondents with high job satisfaction (42,9 %), half of the respondents with fairly high job satisfaction (51,1 %), two fifths of those with average job satisfaction (40,1 %) and two fifths of those who are dissatisfied (44,0 %). It follows from these results that an individual's job satisfaction significantly influences their willingness to reconsider and change their teaching practice. Job satisfaction, in turn, is significantly related to the school climate. School leaderships and those teachers who evaluate the innovative work of teachers as one of the criteria for improving educational work, and who encourage teacher-innovators and participate in their projects constitute an essential pillar of quality innovation work.

3.3 Measures for encouraging innovative teaching

One of the questions posed in the survey was which factors teachers and headmasters see as contributing the most to increasing innovative teaching. We also wanted to see whether the two groups of respondents would differ significantly in their assessments of the importance of these factors. The respondents assessed each factor on a five-level scale, with 5 standing for 'this would be a major incentive for teachers to implement innovations' and 1 standing for 'this would not encourage teachers to implement innovations'

	teachers	R	head-masters	R	t	g	sig
Innovating should be part of every teacher's regular job description	3,41	10	3,95	7	-4,051	64,857	0,000***
Internet databases of articles dealing with different innovations	3,85	7	3,86	9,5	-0,116	1082	0,908
Each school should have a researcher-teacher/ innovator employed, whose task would be to help other teachers design, implement and evaluate innovations	3,64	8,5	3,95	7	-2,474	67,528	0,016**
Improve the school climate with regard to innovative teaching (support of headmasters and other teachers)	3,91	6	3,95	7	-0,305	1085	0,760
innovative teaching acknowledged to a greater extent than now in terms of salary and promotion credits	4,39	2	4,44	1	-0,469	1085	0,639
Reduction of workload for those teachers who are implementing innovations	4,23	3	4,14	3	0,767	1085	0,443
Organizing regular in-service training events focusing on the latest innovations	4,12	4	4,05	5	0,660	1083	0,510
Organizing training programs for teachers focusing on general knowledge of planning, implementing and evaluating pedagogical innovation	4,02	5	4,13	4	-0,944	1082	0,345
Well-equipped schools (accessibility, quantity, quality of teaching aids)	4,40	1	4,21	2	2,141	63,554	0,036*
Help of the school advisory services with finding out about and implementing innovations	3,64	8,5	3,86	9,5	-1,902	63,723	0,062

* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

To sum up the results, teachers believe that the key factors which would encourage them to implement pedagogical innovations are (1) well-equipped schools (accessibility, quantity, quality of teaching aids), (2) innovative teaching acknowledged to a greater extent than now in terms of salary and promotion credits, and (3) reduction of workload for those teachers who are implementing innovations.

The headmasters' top list contains the same three factors, only in a slightly different order: (1) innovative teaching acknowledged to a greater extent than now in terms of salary and promotion credits, (2) well-equipped schools (accessibility, quantity, quality of teaching aids), (3) reduction of workload for those teachers who are implementing innovations.

Assuming ***homogeneous*** coefficients of variation, the t-test showed significant differences between teachers and headmasters in their assessments of the importance of the following factors: 'each school should have a researcher-teacher/ innovator employed, whose task would be to help other teachers design, implement and evaluate innovations', and 'innovating should be part of every teacher's regular job description'. These two measures, on average, are considered more important by headmasters than by teachers', while 'well-equipped schools (accessibility, quantity, quality of teaching aids)' was a factor considered more crucial by teachers.

Teachers' innovation of their own pedagogical practice is a complex and multi-layered phenomenon. In addition to the content aspect of innovation itself, the teacher's personal attitude towards the particular innovation, and towards the process of innovating, is also important. For the successful implementation of a particular innovation the broader social conditions, the position of the teaching profession and the economic perspective are also important. We cannot expect teachers to pursue innovative work when they are facing a daily work overload and if their innovative work is not appropriately valued in a professional and financial sense. If school leadership offered more support and encouragement to innovative work in schools, and provided the necessary assistance for such work, teachers would most certainly undertake innovations more often. Innovative work could then become a key factor in raising the quality of educational work and a key tool for teachers' professional development.

4 Conclusion

Innovativeness and creativity in education, according to the OECD model, is driven by four factors: (1) research, (2) horizontal connections – cooperation between teachers and learner groups, (3) modular structure, and (4) ICT (Istance, 2008). Whether a teacher decides to innovate their teaching of course significantly depends on the individual's attitude towards change. Our research has shown that in general teachers have a positive attitude towards pedagogical innovations. The teachers' attitude towards changing their teaching practice and their willingness to pursue such change is shaped by various factors. A number of studies have shown (Fullan, 1992, Hodkinson& Hodkinson, 2005, Jorgenson, 2006, Valenčič Zuljan, 1996a, 1996b, 1997), that these factors include: staffroom climate, support of the headmaster, opportunities to observe colleagues' classes and exchange experiences with colleagues who are already working on an innovation. It has to be stressed, however, that while general support from colleagues is important and welcome, quality innovations and teacher development require task-oriented interactions (Rosenholtz, et al, 1986), which assume specific forms of communication among teachers such as joint materials production, regular discussion group meetings, lesson observations and peer reviews/ feedback sessions. It is also worth noting, as Fullan and Hargreaves (2000, p. 12) point out, that reforms falter because they do not take into consideration schools as complex wholes.

A teacher's innovation competence is certainly one of the key conditions for meaningful, successful change of educational practices. The teachers and headmasters surveyed in our study, overall, consider themselves to be well prepared for planning, implementing and evaluating pedagogical innovation, but the best conditions which would encourage this process are not always provided. From the perspective of teachers and headmasters, quality equipment of schools, pay rises, promotion credits and reduction of workload are those factors which would most stimulate teachers to engage in implementing innovations in their educational practice.

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